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ABSTRACT

This study presents composite profiles of teachers who were interviewed in order to assess how they are being affected by the challenges and opportunities presented by computer technology use. In-depth interviews were held with 76 teachers from 10 sites around the country, and the interview data were analyzed to identify themes and to construct seven composite profiles of teachers who articulated those themes. The profiles present the following points of view: deciding not to use computers; looking forward to teaching with technology; using computers in an elementary classroom; using computers in special education; teaching computer science and computer literacy; integrating computers into the secondary mathematics curriculum; and training teachers at the district level. The findings drawn from all the interviews address: (1) influences on teachers' decisions about teaching with technology, their beliefs, external mandates and opportunities, and access to resources and support; (2) effects of computers on teaching style, classroom management, and teachers' roles; and (3) resources and support teachers want, hardware and software, effective training and ongoing assistance, visions of teaching with technology, layers of administrative and technical support, and greater influence on educational technology policies, applications, and use. It is noted that these findings suggest that policy efforts focus on the computer as an instructional tool, and that an integrated system of resources is necessary to support such use. A copy of the telephone interview survey instrument is appended. (76 references) (EW)

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HOW TECHNOLOGY AFFECTS TEACHING

Technical Report

March 1988

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HOW TECHNOLOGY AFFECTS TEACHING

March 1988

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In particular, we would like to thank our colleagues in the ten sites who identified and located the teachers we interviewed -- a remarkable achievement given that teachers were out of school for the summer.

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EXECUTIVE SUMMARY

The principal objective of this study is to assess how teachers are affected by the challenges and opportunities provided by computer technology. The study is based on indepth interviews with 76 teachers from 10 sites around the country. The respondents at each site and as a group represented a diversity along a number of variables: subject area, grade level, function and role, type and extent of computer use, and gender. They were asked:

- how and why teachers use computers;
- what training and support have been available to teachers;
- what effect computers have on teachers and students;
- what influence teachers have and might have on technology and on how it is used.

Interview data were analyzed to identify themes and to construct seven composite profiles of teachers that articulated those themes. The composite teacher profiles represent a range of users and nonusers of technology, a variety of roles at the elementary and secondary school levels, and different perspectives on the educational uses of computers. The profiles portray the following points of view:

- Deciding Not to Use Computers
- Looking Forward to Teaching with Technology
- Using Computers in an Elementary Classroom
- Using Computers in Special Education
- Teaching Computer Science and Computer Literacy
- Integrating Computers into the Secondary Mathematics Curriculum
- Training Teachers at the District Level

The findings drawn from all the interviews address: (1) influences on teachers' decisions about teaching with technology teachers' beliefs, external mandates and opportunities, and access to resources and support; (2) effects of computers on teaching style, classroom management, and teachers' roles; and (3) resources and support teachers want hardware and software, effective training and ongoing assistance, visions of teaching with technology, layers of administrative and technical support, and greater influence on educational technology policy, applications, and use.

The findings suggest that policy efforts focus on the computer as an instructional tool, and that an integrated system of resources is necessary to support such use. Teachers and schools need information about possible approaches for integrating technology into instruction and for supporting teachers in these efforts. Assessment and documentation of the himplementation process, student learning, and other effects are essential.

The report concludes that it is premature to identify models and exemplary programs and that efforts should be devoted to experimentation and dissemination, taking full advantage of all available public and private resources.

INTRODUCTION

This study provides an opportunity for teachers to speak to policy makers about their experiences with educational technology. It was designed to clarify how teachers use computers, what has influenced their decisions, the effects that new technologies have had in their classrooms, how they would like to use computers, and the resources and support they seek. By talking directly with teachers, we hoped to bring their views to bear on the policy decisions that will affect teachers as they continue to integrate new technologies into their classrooms.

COMPUTERS CAN SERVE A RANGE OF EDUCATIONAL PURPOSES

Computers can be programmed to serve an almost unlimited range of purposes. They have been likened to a Rorschach card (Amaral, 1983) onto which educators can project their myriad goals and assumptions about the process of teaching and learning.

Equipped with appropriate software, computers can reflect a variety of educational approaches. At one extreme is an image of education as the transmission of fixed knowledge from teacher to student. At the other extreme is an image of education as invention, emphasizing the student as an independent maker of knowledge. Between these two lies an image of teachers and students interacting to construct shared knowledge, in a joint effort to make sense of the world around them.

Each image embodies an educational philosophy and implies a role for computer technology (Educational Technology Center, 1984). Broadly speaking, the educational use of computers can be discussed in terms of two potential roles for technology: as medium and as tool. As a medium the computer serves to instruct or inform the user, for example, through drill-and-practice programs, tutorials, simulations, or educational games. As a tool, the computer serves to help the user accomplish a task. Tool software may serve general purposes, such as wordprocessing, database management, or spreadsheet applications, or more specific purposes, such as gathering and displaying scientific or mathematical data via specially designed and programmed devices.

Computer-based educational activities can also vary widely in their relationship to the core school curriculum and to standard classroom practice. Some of these activities -- desktop publishing software used to produce publicity for the school play, for example -- may have no direct connection with the basic instructional program. Other computer-related activities may constitute an add-on to the traditional program, as is commonly the case with programming and computer literacy courses. Or the new technologies may have a direct effect on the core academic program, ranging from ancillary, to central, to transformational.

Given the range of possible uses of computers, coupled with the vast variety of educational goals and approaches embraced by teachers, we expected to hear many different stories about the impacts of computers and the kinds of training and support that teachers want. Our expectations were further shaped by prior research on the

implementation of educational innovations in general and the introduction of computer-related technologies in particular.

PRIOR RESEARCH ON THE IMPLEMENTATION OF NEW EDUCATIONAL TECHNOLOGIES

During the past two decades, research on educational innovations has increasingly focused on the teacher as the central character in implementing new instructional practices (Berman, 1981; Crandall et al., 1982; House, 1979; Huberman et al., 1983). Whereas earlier studies of educational change focused on the dissemination of knowledge about exemplary practices (Havelock, 1969), more recent work has focused on the process of carrying out innovations. It has revealed that teachers adapt innovations in light of their own goals, their accustomed practices, the culture and organizational structure of their school context, and their interpretations of the information they receive about new approaches (Berman & McLaughlin, 1974 and 1977; Doyle & Ponder, 1977; Farrar et al., 1981; Goodlad, 1984; Lieberman, 1986; Sarason, 1971). Researchers who have looked particularly at computer-based interventions stress that teachers' needs must be taken into account (Kimmel, Kerr, & O'Shea, 1986), preferably including them as partners in research and development designed to incorporate new technologies into their classrooms (Sheingold, Martin, & Endreweit, 1985).

Teachers alone, however, cannot initiate and sustain innovation without training, resources, and support. Innovation is greatly affected by the amount and quality of assistance (Huberman & Miles, 1984). This is particularly true for computer-based innovations. Teachers need training in content, technology, and classroom management (Cline et al., 1986; Sheingold, Martin, & Endreweit, 1985; Watt & Watt, 1986), including specific examples of ways to connect the innovation to their regular courses and classes (Doyle & Ponder, 1977; Mohlman, Coldarci, & Gage, 1982). When an innovation requires teachers to rethink their subject matter, as is often the case when using computers, they benefit from the assistance of an "advisor" or "helping teacher" (Zigarmi, 1978; Rauh, 1978; McDonald & Naso, 1986). This person should not merely advise, but actually alleviate the burdens of innovation through preparing materials and teaching or assisting in the classroom. Another form of sustained assistance that teachers find particularly valuable is consultation with colleagues who are attempting to adapt similar innovations in their own classrooms (Cline et al., 1986; Kimmel, Kerr, & O'Shea, 1986; Sheingold, Martin, & Endreweit, 1985; Stalling, Needels, & Stayrook, 1978; Watt & Watt, 1986; Wiske, 1986).

Several research projects have looked closely at the resources teachers need in order to incorporate computers into their classrooms. These include the Educational Technology Center's laboratory sites project which studied the process of implementing research-based innovations in science, mathematics, and programming in several secondary school sites (Lampert, 1988; Wiske, Shepard, & Niguidula, 1988); studies of the IBM Model Schools Program (Cline et al., 1986; Stecher & Solorzano, 1987; Watt & Watt, 1986); studies of the *Voyage of the Mimi*, an interactive multi-media curriculum (Martin, 1987); and research on the uses of Logo in classrooms (Hawkins, 1985;

Hawkins & Sheingold, 1986). All have pointed out the complex logistics associated with acquiring access to necessary hardware, software, and related equipment and materials. They have also revealed that new technologies alone are not sufficient to alter classroom practices and curriculum. To create deep changes in these basic features of the educational setting requires sustained professional assistance. Often it also requires shifts in organizational structures and routines. Administrators, including principals, department heads, and superintendents (Farrar, 1987; Loucks et al., 1982; Wiske, 1986), play a key role in supporting change by providing leadership and incentives from tangible rewards to moral support.

ORGANIZATION OF THIS REPORT

This report reflects the organization and chronology of the study. The methodology section describes the selection of respondents, the design of the interview questionnaire (based on the literature summarized above), and the process of collecting and analyzing interview data. The data are synthesized and reported in a series of profiles of teachers, each of which represents a subset of the teachers we interviewed. These profiles are listed below along with the approximate number of interviewees represented by each one:

- Charles Perry: Deciding Not to Use Computers (9)
- Abby Miller: Looking Forward to Teaching with Computers (14)
- Laurie Adler: Using Computers in an Elementary Classroom (7)
- Chris Johnson: Using Computers in Special Education (4)
- Carolyn Hemenway: Teaching Computer Science and Computer Literacy (8)
- Marilyn Gordon: Integrating Computers into the Secondary Math Curriculum (11)
- Alan White: Training Teachers at the District Level (12)

The discussion section complements the portraits by summarizing patterns that emerged across the entire set of respondents and discussing them in light of related research. Finally, we discuss the policy considerations implied by our findings.

METHODOLOGY

OVERVIEW

Teachers from ten diverse sites across the nation, reflecting a wide range of backgrounds and experiences, voiced their opinions regarding the use of computers in education. We collected data through in-depth telephone interviews. Among the topics investigated were computer use, training and support, effect of computers on teachers and students, and teachers' influence on technology. Based on a comprehensive review of the data, we constructed composite teacher profiles. The methodology used in this study is presented in four sections:

- Sample: a detailed description of the sample focusing on demographic information.
- Interview Questionnaire: a discussion of the interview questionnaire, including the rationale for selecting this format and the design of the questionnaire.
- Data Collection: a review of the steps involved in data collection.
- Data Analysis: a discussion of data synthesis, with attention to identifying themes and constructing composite teacher profiles.

SAMPLE

The selection of the sample was guided by several factors. We included in the sample teachers from many subject areas and grade levels to ensure that the data would reflect the full spectrum of teaching disciplines and educational computer uses. Computer users and non-users were represented, and we interviewed approximately equal numbers of women and men. Regional diversity afforded us results that were not unduly influenced by any one geographic setting.

In early summer of 1987, we selected ten regionally-diverse school districts, including urban, suburban, and rural sites across the country. The following sites were chosen: Casper, Wyoming; Contoocook Valley, New Hampshire; Fairfax County, Virginia; Houston, Texas; Lexington, Massachusetts; Mercer Island, Washington; Minneapolis, Minnesota; New Orleans, Louisiana; San Diego, California; and Washington, D.C. Next, using informal networks, we obtained the names of potential respondents at each site. In selecting the sample, we attempted to balance each teacher's position, extent and type of computer use, and gender. From this pool, we contacted teachers by telephone, asking if they would participate in a study investigating the effect of technology on teachers. We explained that participation would involve being interviewed on the phone for approximately one hour, and assured the teachers that, although the findings would be shared, respondents would not be identified by name. Most teachers who were contacted agreed to participate.

Seventy-six teachers, all from public school systems, participated in the telephone interviews. The majority (70%) of respondents were full-time classroom teachers; the others held different positions, including those of teacher trainer and

computer coordinator. The teachers were distributed fairly evenly along the K-12 spectrum: 34 percent taught at the elementary level (grades K-6), 24 percent taught at the junior high level (grades 7-8), 33 percent taught at the high school level (grades 9-12), and 9 percent taught at more than one school level. Forty-nine percent of the respondents taught only one subject: math (20 percent), science (8 percent), social studies (6 percent), computer science (4 percent), English (4 percent), special education (4 percent), and foreign languages (3 percent); the others taught several subjects or coordinated specialized resources. School populations ranged in size from 82 to 2400 students (mean = 955; median = 820).

Most respondents had considerable teaching experience; the range extended from 1 to 33 years (mean = 16; median = 18). On the whole, teachers in the sample were well-educated; 45 percent had received an advanced university degree. Slightly more than half (59 percent) of the teachers were women. Approximately half (47 percent) of the respondents had one or more computers in their classrooms for the entire year, while 5 percent had a computer in their classrooms only occasionally. Thirty-eight percent of the respondents described themselves as extensive computer users, 20 percent as moderate users, 18 percent as occasional users, and 24 percent as non-users. The great majority (92 percent) had received either formal or informal computer-related training.

INTERVIEW QUESTIONNAIRE

We chose a telephone-interview format for data collection. This approach offered several advantages. First, the one-on-one interaction enabled the interviewer to probe individual responses. Second, telephone interviews allowed us to collect data from teachers across the country within a short time-period at minimal cost.

With the format established, the research team developed a preliminary version of the questionnaire. The questionnaire, guided by our review of the literature and our own prior research, focused on four topics: (1) computer use, (2) training and support, (3) effect of computers on teachers and students, and (4) teachers' influence on technology.

The team then conducted two focus group sessions with teachers in metropolitan Boston. One session involved computer "users" (11 teachers), and the other involved "non-users" (9 teachers). During these informal discussions, lasting approximately three hours, we explored research themes and tested questionnaire items. The discussions, structured around the questionnaire items, served to delineate the range of responses we could expect during the telephone interviews. Based on the findings from these sessions, we refined the questionnaire (see Appendix for the questionnaire).

DATA COLLECTION

Six researchers conducted the telephone interviews during a four-week period in July and August 1987. Each interview was audio-taped (with the respondent's permission). We first asked general questions to investigate each of the four major topics (computer use, training and support, effect of computers on teachers and students, and teachers' influence on technology). We used follow-up probes to elicit

detailed accounts. All questions were phrased to avoid leading the answers in a specific direction. In addition, we asked factual questions regarding demographic information.

At the conclusion of each interview, the researcher wrote extensive notes for each of the four areas under investigation, and transcribed some vivid or insightful remarks to illuminate specific viewpoints. Participants received a small honorarium for taking part in the study.

DATA ANALYSIS

The goal of data analysis was two-fold: to identify recurring themes that emerged in the interviews and to construct composite teacher profiles that articulated these themes. The research team sifted through the notes from the interviews by questionnaire category; that is, we examined what teachers in the study had to say about type and extent of use, training and support, the effect of computers on their professional lives, and the role teachers played in decisions affecting computer use in their school or district. We identified primary themes in each category, and reexamined the data to confirm or revise the team's preliminary assessment. Each set of notes was reviewed to confirm patterns, distribution, and frequency of response. We then organized our findings into a series of composite teacher profiles, each giving life to one or more major themes. We decided to vary two parameters in each profile: extent of computer use and teacher function. We chose the first criterion, extent of use, because we wanted to tell the stories of teachers who made extensive use of computers in their classrooms, as well as the stories of nonusers. We chose the second criterion, teacher function, because we realized that an effective way to tell part of the story of computers' effect on teachers was to describe real teachers doing real jobs such as teaching in elementary classrooms, special education classrooms, or high school English classrooms.

Each profile is introduced by a summary paragraph that highlights the themes developed more fully in the profile itself. We reviewed the profiles for accuracy, and prepared a discussion section to help the reader interpret the profiles in the context of the total sample and in light of other research.

TEACHER PROFILES

The composite teacher profiles articulate teachers' opinions regarding the use of computers in education. Each profile depicts a teacher in a distinct school setting. This specific context creates an opportunity for voicing a representative point of view within the educational community. It should be emphasized that each teacher profile is a composite based on elements taken from approximately four to twelve of the interviews. Therefore the profiles maintain the flavor of the actual responses while ensuring the confidentiality of the participants. Note that the names attached to each profile are fictitious.

The following profiles present multiple perspectives on educational uses of computers:

- Charles Perry: Deciding Not to Use Computers
- Abby Miller: Looking Forward to Teaching with Computers
- Laurie Adler: Using Computers in an Elementary Classroom
- Chris Johnson: Using Computers in Special Education
- Carolyn Hemenway: Teaching Computer Science and Computer Literacy
- Marilyn Gordon: Integrating Computers into the Secondary Math Curriculum
- Alan White: Training and Supporting Teachers

CHARLES PERRY: DECIDING NOT TO USE COMPUTERS

Composite character Charles Perry is a high school English teacher and department chairperson. He is also a staunch nonuser of computers. A one-day in-service course several years ago left him feeling stupid and unimpressed by educational technology. Seeing no potential in computers, he has sought no further training. Charles has serious reservations about the effect of computers on teaching and learning. He worries that they will become a mental crutch, fostering intellectual laziness among students and pedagogical laziness among teachers. He fears losing the traditional "center-stage" role he now has with students. Among his colleagues he has talked mostly with those who share his disdain for technology. As a result he lacks exposure to effective use of computers and tends to blame the machines for the ineffective ways people use them.

Charles Perry chairs the English Department at an affluent suburban high school of 1100 students. A teacher with 21 years of classroom experience, Charles has a M.A. in English. What distinguishes him from many other teachers is his decision not to use computers even though he has ready access to them. Unlike those who believe they would use computers if only they had the opportunity, Charles has no intention of teaching with technology. His stance in some ways resembles that of former computer users, who have become disillusioned with technology due to management problems or inappropriate software.

Charles's decision not to use computers is based on several factors: bad training, fears about the effects of computers on learning and teaching, and lack of a compelling vision of how technology could enhance the curriculum.

Charles took a one-day in-service computer course ten years ago "and got nothing out of it. They went so fast; I felt so stupid. The manual was unreadable," he recalls. Since then he has observed a number of colleagues going through similar training experiences, which he blames on computer enthusiasts who "go flying off without you and make you feel stupid."

Charles offers no apologies for his decision not to use computers in his teaching. "Sure, with time and better instruction I could learn how to use them, but the computer just isn't important to me," he says. "I'd rather spend my summers writing than taking computer classes." By all accounts, Charles is a masterful teacher who knows exactly what he wants to accomplish in the classroom. He sees no need to alter his teaching practice to accommodate the new technology, and more important, as a self-described "19th century person kicking and screaming my way into the 20th century," he is profoundly skeptical of the usefulness of computers in helping him achieve his pedagogical aims. "What's it for?" he asks in an exasperated tone. "I'm still wondering what a computer is supposed to do; I know it cannot think for you. Plato and Aristotle -- were they better off or worse off because they didn't have these machines? I don't see that thinking -- the kind of thinking you'd want for citizenship -- is enhanced by these machines."

In large part, Charles's opposition to computers is based on deeply held -- though sometimes naive -- concerns about their effect on learning. For example, he notes problems with word processing. "I'm finding that my kids do all their papers on wordprocessors and they don't seem to be as long or rich as they were when done in longhand and then typed. It seems the computer may get in the way of the interaction between thought and expression. Do we disassociate ourselves from the process of writing when we use a machine? We should study this carefully," he says.

The problem, as Charles sees it, is that many students are satisfied with turning in their first drafts. Seduced by the cleanness of the copy that comes out of the printer, they neglect to edit or rewrite. "When you're writing by hand or working from a printed page, you can go back, see what you've done, pencil in the margin, and look up words. Having kids turn in things that are neat and readable has been a godsend," he acknowledges, but "they think that because it looks neat, it's done." He believes that until teachers as a group demand more rewriting they're not going to see much improvement. And he worries that too many teachers, like their students, are fooled by the neatness of computer-produced papers. Thus, unlike many teachers of writing, Charles fears that wordprocessors discourage rather than facilitate editing.

Charles's fears about the effect of computers on learning are not limited to word processing. He worries that students' reliance on computers will lead to the loss of important mental skills. "If you don't have a computer and the appropriate diskette in hand, you're not going to be able to go back to the information that has slipped your mind," he says. "Learning on the computer is much easier, but it's not as good [for] retaining [what you've learned]. If [students] learn on the computers and then take a state exam, they'll be lost unless they're allowed to use a computer." Underlying Charles's concern is an implicit view of the computer as a mental crutch whose use will cause students' minds to atrophy.

Charles also views computers as problematic for teaching. Like many good teachers, he cherishes the "on-stage," performing aspects of his job. A good actor and an effective class leader, he derives a great deal of pleasure from being the center of attention. He sees computers as a source of competition for students' attention. Moreover, he argues, computers would undermine his control of the classroom. He suggests that they may have the greatest appeal for teachers who are less successful at holding the attention of their students and might therefore welcome the opportunity to try a different pedagogical approach.

In addition, Charles associates computer use with a style of teaching he mistrusts. He points to a coworker, "a very casual kind of person," who believes that students learn a great deal through play. Her students often use computers to play games, and Charles doubts that they are learning as much as they would from traditional instruction. He is also dismayed by what goes on in the computer lab next to his classroom; he describes it as a chaotic place where students receive little supervision. He is afraid that the technology is tempting teachers to relinquish their instructional role, becoming "just facilitators of student computer use."

A related concern is that some teachers are using the computer as a babysitter. "Unfortunately," Charles says, "many teachers are not very dedicated to their teaching,

and many of them take the computers as a pretext to do something else, leaving the students alone [to learn] on the computer what they should be teaching in the classroom." He believes that proper use of computers in schools requires close supervision.

Finally, Charles fears that computers will disrupt the student-teacher relationship. He has heard from a colleague who teaches foreign languages that computers make it difficult for a teacher to see what students are learning. In particular, this colleague recounted how, with drill-and-practice or tutorial software, "a kid can just push a button and the teacher has no way of knowing whether he has the wrong answer or not, unless the teacher happens to be standing right behind him. If the student gets a wrong answer, the computer says "no, try again," so he pushes another button. There is no way for the teacher to know if the kid is guessing blindly or learning. Nothing feeds back to the teacher about how each kid is doing." Lacking contact with teachers who find that observing their students at the computer provides them with a valuable window on thinking and learning, Charles has become convinced that technology comes between teachers and students.

At least some of Charles's objections to technology are based on partial information and lack of exposure to uses that might enhance what he wants to do in the classroom. He sometimes blame the computers for problems with the ways people use them. For example, he worries that computers encourage students' laziness in writing and teachers' tendency to require too little of their students, but he finds it difficult to imagine how, with appropriate instruction, computers might help to overcome these problems and actually improve students' composition skills. His natural skepticism about machines leads him to write them off rather easily, and neither in-service training nor informal contact with teachers who use computers effectively has provided a vision that alters his misgivings.

ABBY MILLER: LOOKING FORWARD TO TEACHING WITH COMPUTERS

A rural elementary school teacher-principal, composite character Abby Miller is eager to introduce computers into her school but has to contend with conflicting priorities and policies at the state and district levels. Her district maintains a moritorium on computer spending, despite a recent state-mandated computer literacy requirement. At the building level, however, teachers have decided to circumvent the moritorium by using privately donated funds to purchase the school's first three computers. Abby is torn: she realizes that the lack of public spending produces home-school and school-to-school inequitites, but she appreciates one advantage of using private money, that building personnel can decide exactly how to spend it. Especially in her small school with its teacher-principal, this has meant a high degree of teacher involvement. Until now, Abby has not encouraged teachers to seek training -- she saw no point unless they had access to equipment so they could use what they learned. Now she hopes to provide a hands-on, mentor-like kind of training, modeled after her own experience learning from a friend.

Abby Miller taught third grade for four years in the Midwest before taking a job as the sixth-grade teacher in a rural consolidated school in the Northeast. Two years ago, when the teaching principal in that school retired, Abby replaced her. She is responsible for the day-to-day functioning of the school's five classrooms in grades one through six, while the school's supervising principal, shared with six other small schools in the area, attends most of the central district meetings with the superintendent and curriculum coordinator and is responsible for top-level decisions.

Abby's school has no computers and she has never used them in teaching, but the effect of having her own computer on her freelance writing has made her eager to introduce them into the classroom. Unfortunately, her hands have been tied by a district moritorium on computer spending, pending the development of a clear philosophy and plan for integrating the computer into the total educational program and insuring a fair distribution of hardware. The district has continued the moratorium despite passage of a state-mandated computer literacy requirement for all students graduating from high school, starting in 1989. Abby remains frustrated by the distict's cautious approach, feeling that teachers need experience with computers before they can know what to do with them in the classroom.

When a private donor in her town offered a sizeable contribution directly to the school for "whatever the staff thinks is important," Abby called teachers together to consider how to spend their windfall. With her encouragement, they wrestled as a group with the decision, considering several options, including playground equipment, school trips, and video equipment, as well as computers.

The first-grade teacher and the fourth/fifth-grade teacher had used computers to do accounting for their husbands' home-based businesses. The second-grade teacher, although somewhat skeptical, was intrigued by her three grandchildren's intense

interest and communication as they played games on a home computer. The third-grade teacher's initial response was the most negative: "Are you kidding? I'm forty years old. I don't need another aggravation in my life!" Eventually, the group was swayed by the first-grade teacher's argument, supported by the recent state mandate, that computers "are going to be with us the rest of our lives, and the children are going to grow up in a world that is becoming more and more computer-oriented." Abby viewed this decision as a way to circumvent the moritorium and get computers into her school.

Abby has thought carefully about how to introduce the technology into the building and is glad to be able to involve teachers actively in decisions that under other circumstances might be made by district administrators. Not wanting computers to create divisions within the faculty, she ordered three Apple IIes with Imagewriter printers so that each system will be the same. Then, she consulted with teachers about where to place them. One computer, they decided, will go in the teachers' work area so they can use it for their own work. Abby plans to find a variety of simple applications to help them accomplish job-related tasks, such as grading, writing notes to parents, and preparing teaching materials, more effectively. She hopes this sort of use will acquaint teachers with the computer's capabilities and whet their appetite to learn about classroom use.

Abby and her colleagues are taking the long view in introducing the computer into the curriculum. They want students to see the computer "as a useful tool," not just a game machine. While they want the computer to become part of each curriculum area and to be used with all students, they don't want to spread their new resource too thin; they recognize that most teachers need to become computer literate themselves before they can use the machines effectively in their teaching. Thus, the teachers decided to place two computers in Abby's classroom for the first year. Abby will use two software packages with her students: the *Bank Street Writer* word processor and the Logo computer language. Once she teaches the sixth graders to write, revise, and publish their writing with the computer, she hopes they will be able to teach the rest of the students in the school. Later, she plans to add Logo. She wants all students to have a chance to learn to use computers, but for the present she has to be satisfied with giving grades one through five just the promise of computer literacy, knowing that "all students will eventually become sixth graders."

Abby's ideas about how to train teachers to use computers have been shaped by her own learning experiences. The little formal training she had, a course on DEC computers through a community education program, disappointed her: "There was no computer to practice on and the course was about *using* the computer, not about *teaching* with the computer. Either way, it seemed pointless since I didn't have access to a computer." By contrast, she remembers the time a friend showed her how to use a computer for writing. He showed her only what she needed to know in order to do a task, and when she was ready, he showed her more. "I learned what I wanted to learn. It wasn't as if *he* decided, the way an instructor might in a classroom or in-service," she recalls. Abby would like to use this model with her colleagues next year. She wants them to know they have a friend who can give them individual help. She herself would like access to a friend, too, like the high school resource teacher, Terry Skinner, who she knows is willing to help other teachers. Unfortunately, the high school where he

teaches is 23 miles away, so getting together is difficult. Abby recognizes that training takes time. Remembering how important long stretches of time in an unpressured setting were to her own learning, she plans to encourage teachers to take the computers home during weekends and vacations.

There is some support in Abby's district for teachers' professional development in instructional uses of computers, but the spending moratorium has squelched enthusiasm. "It's not something they are pushing like the T.I.P. training (Theory Into Practice of Madeleine Hunter) or the Reality Therapy (of William Glasser) workshops. A teacher has to want it," says Abby. In this rural setting "it's taken longer to convince people that computers are going to stay." Even without funding, she would like to take a summer institute on teaching writing with computers: "Getting paid is not as important to me," she says, "as the opportunity to learn more about this subject."

LAURIE ADLER: USING COMPUTERS IN AN ELEMENTARY CLASSROOM

Composite character Laurie Adler represents teachers who use computers in their elementary school classrooms. Like many of these teachers, her introduction to technology was less than smooth. As a third-year teacher, she was given a computer for her classroom, but she received no accompanying training, limited software, and little support from administrators. Faced with a sink-or-swim dilemma, Laurie decided to swim. She began experimenting, first with games, then with drill-and-practice software, and later with applications software. Gradually, she evolved a mode of computer use that fits her individualized approach to teaching. She uses the computer as a classroom learning station where students use software in math, reading, and especially writing. She feels the computer gives her an added means of reaching and motivating children and that it promotes a sense of community as students work together in pairs or trios. Computer use has been professionally rewarding for Laurie, although the rewards are intangible.

Laurie Adler teaches first grade in an elementary school with approximately 625 students. Situated in a large town on the West Coast, the school serves a predominately middle-income population. Last year, Laurie had 26 students in her class and was responsible for teaching them "everything" except art, music, and gym.

Laurie's first exposure to computers came four years ago, when as a third-year teacher she was unexpectedly given one to use in her classroom. At that point, her only training had been a one-day computer workshop that left her feeling uncertain she would ever understand how to use such complex machines. Although computer use was not a required part of the first-grade curriculum, when the equipment appeared in her classroom she felt expected to "dive in and get wet."

Currently, Laurie's school has 16 computers, most of them Apple IIes located in classrooms of teachers like herself. Not all those teachers have been as adventurous as Laurie, however; she knows of classrooms where the computer sits unused, and she blames school policy -- or lack of one -- for this situation. She feels it's short-sighted and unrealistic to give teachers hardware without providing the necessary training and support. "People are left too much on their own, so if they aren't curious, they just don't get involved."

She recognizes that many teachers, especially those who are older and close to retirement, need some prodding. Next year, for those who "tend to make excuses and pretend they don't have time" to use computers, the district will provide a basic introductory course which Laurie jokingly calls the "Deathly Afraid of Computers Class." Although the school does not formally require teachers to use computers, Laurie hopes to do a little prodding herself, now that she feels more comfortable using the computer in her own classroom. "I was afraid, too, at first, but it's not that hard. You just need time and patience." She credits an enthusiastic workshop instructor a couple of years ago with helping her realize she didn't have to know everything "because a lot of

times in a computer situation people are learning together -- students and teachers are learning together. The main thing is the teacher's confidence that even though she doesn't know exactly what's happening right this minute she still has control over the learning situation and will figure it out." This kind of encouragement would have been extremely reassuring early on, Laurie says, when it was difficult for her to admit that her grasp of the material was shaky.

Laurie notes that her use of computers has changed over the years from occasional use as "a novelty thing" for playing games to daily use as a classroom "learning station." "I've found that it just fits in with the way I like to do things in school. Having it helps me to keep more of an individualized approach to teaching." Besides having individual students work at the computer, she uses it for whole-class lessons and small-group work. Occasionally she can commandeer an extra machine from several that float throughout the school or are used mainly for administrative purposes ("if I'm aggressive, I take one on a rollaway cart when nobody else is there, and then when they come for it I say we're in the middle of using it and I can't give it back!").

Though her students use some math and reading software, their biggest success has been with writing. She believes their stories and poems are far superior to what they would have produced with paper and pencil, and she thinks that the computer helps lengthen their attention spans and teach them patience. They can exercise control over what they see on the monitor and, if patient, can get satisfying results. She would like to explore other uses of the computer, but she hasn't had the chance to preview much software since her school's selection is limited and shared among many classes.

Remembering how long it took her to become comfortable with computers, Laurie tries to demystify things quickly for her first graders: "I open that machine right up so there's absolutely no fear or apprehension about what's going on in there." She also teaches her students correct vocabulary "so they don't say 'this little box' when they mean the disk drive," and she refuses to do things like boot disks for them. They have occasional accidents, but she finds that children bounce back much more easily than adults.

Initially, Laurie found that having the computer learning station created lots of interruptions in class as children came to her with questions about hardware or software. "What has worked for me," she reports, "is to have a rotating master computer pal, who really knows a piece of software and can answer questions for the other kids." Gradually, she has noticed that the computer encourages a sense of community in her class; even aside from the pal system, students often choose to work with a partner.

Laurie is convinced that elementary school children should use computers. "I think that as they grow up students are going to need to be familiar with the pitfalls as well as the wonders of the computer. I think it's going to be such a strong instrument that they will need to know how to be in command of it to even survive." Recent technological advances, she points out, demand that students develop different kinds of problem-solving skills than before. "I'm very much against mundane dittoed work, and I just don't think that it's very probable that any of our kids are going to have to divide nine trillion by 34,230, and do 15 pages of math. No profession is going to demand that.

They might have to know the process, but they're not going to actually have to do that kind of computation in their lifetime. So I'd rather that they grow up with technology and be familiar with it and put it to their best interests."

Although using computers has garnered Laurie no monetary or status rewards thus far, she has reaped intangible satisfactions. The rewards come, she says, "when children choose to stay after school, to come in at 8:00 in the morning [to work on the computer], or when parents thank you for the extra time you've put in. I really appreciate that." An additional reward has been a change in her relationship with other teachers. She has surprised herself, at times, by talking with her colleagues "about things I've done in the classroom. I feel more self-confident in my job, and that has made me come across as a stronger, more assertive, and more positive person."

CHRIS JOHNSON: USING COMPUTERS IN SPECIAL EDUCATION

As a teacher of high school students with special needs, composite character Chris Johnson represents teachers who have been initiators and innovators in using computers. In a large system, where the district coordinator and administrators make most of the decisions, Chris has used a blend of soft-spoken sincerity and political savvy to "work the system" so that he and his students have access to the technology he believes can improve their school experience. He is articulate about the benefits to his students in motivation, structure, and social interaction, and he cites benefits to his teaching and professional growth as well. Fortunately for Chris, his school system has provided him with several tangible rewards for the technological interest and expertise he has developed.

Chris Johnson teaches special education in a large urban high school in a mid-Atlantic state, a position he has held for the past ten years. Working with learning disabled, mentally retarded, physically handicapped, and speech impaired students, he has used computers in his teaching since 1981 and, at present, has two Apple IIe computers in his classroom. In addition, he has access to ten IIes in one of the four computer labs in his building.

Chris's initial interest in computers was sparked by a graduate course on the fundamentals of hardware and software and how these might be integrated into the high school curriculum. With this introduction under his belt, he quickly took the initiative in pursuing an emergent interest in software development for learning disabled (LD) students, enrolling in district workshops and pursuing computer studies as part of his Ph.D. program. Now, he makes sure he keeps exploring on his own. Having a computer at home helps with his learning and experimentation: "Each year I add one new major software [application] to my repertoire . . . something I use personally." By first becoming comfortable with software at home, he is able to be more attentive to student needs and curriculum possibilities when he introduces it into the classroom.

Chris saw the promise of computers for individualizing instruction and enhancing social interaction among his LD students, but he recognized that available software would need to be adapted for special populations or that new software would need to be "invented." Some district personnel wanted him to learn Logo, but he knew it wasn't appropriate for his students. Furthermore, he couldn't use most existing elementary school software, even though many of his students were still working on skills covered in the elementary curriculum: "It was embarrassing to ask kids to use elementary school software when they were in high school. They just don't want to deal with apples and clowns when they're high school age."

Chris decided it was up to him to develop software that would be suitable to the structure and pacing of an LD classroom. He wrote a "mini-grant proposal to adapt the materials" that appeared most promising for special educational use. He devoted after-school time and two summers to the project, seeking help from computer professionals,

LD colleagues, and several high school honors students. He was so excited by the challenges of computer technology that he wrote another grant proposal aimed at implementation and was awarded two Apple IIe computers for his classroom. This enabled him to get hardware into his classroom well ahead of its introduction into most classrooms in the district.

Even with these two computers, however, Chris has to jockey continually for access to more computer time. Prior to each term the district's computer coordinator meets with school administrators and department heads to schedule the lab. Given the competition for these spaces and the relatively small size of his department (in number of teachers and students), Chris is not always able to get the two hours of lab time per pupil that he would like. Undaunted, he has become adept at the politics of negotiating lab time and other computer-related issues, learning "which people to talk to and who has a little influence with a school committee member." When he realized that the business department cornered much of the available lab time, he decided "to get a friend in the business department." Two of his time periods in the lab are a direct consequence of this "friendship."

Chris is willing to go to these lengths to get computer time for his students because he sees how the technology enhances their learning. He now considers computers a central component of his teaching approach. The small size of his classes has made it possible to use the computer as "the focus for whole-class demonstrations and decision making as well as for individual use." For many students, just learning simple keyboarding helps them to improve their motor skills. For one physically handicapped student who strokes the keyboard with a small wand fastened to a headpiece, the computer permits an entirely new way of communicating with teachers, parents, and other students. For her and others, the computer provides a way to cope with the environment that has never been available before.

Chris has discovered other creative uses for the computer. For example, for the past three years he has used the *Printshop* program as a business venture to teach students vocational and social skills. Students prepare newsletters, banners, and other printed matter which they then sell within the school and wider community. He has also found classroom uses for various database, graphing, and spreadsheet applications. He has worked closely with teachers in the English component of the LD program to help students learn wordprocessing skills. For the first time, he reports, "the LD student can produce something legible, something that looks like it could be put in a book." This is just one example of how the computer motivates students and boosts their self-esteem. Says Chris, "they migrate toward it when given the chance and are often happy to stay after class to continue work in progress."

Perhaps the most compelling of Chris's reasons for using the computer is its capacity to put "nonhandicapped kids in touch with handicapped kids and to allow the handicapped kids to be perceived as competent at something, which doesn't often happen to them." Chris has instituted a peer buddy system to promote this process. He pairs an LD student with a mainstream student to work on computer activities. "My retarded kids can whup those regular kids on some of the memory and spelling games. I

think it's one of the first times that regular kids have perceived this normal competency level in handicapped kids."

Chris also expects that later in life many of his students will find themselves in situations where they will be called upon to interact with machines. Whether in jobs requiring them to perform data entry procedures or in circumstances where mechines will help them cope with their disabilities, he wants them to be able to draw upon their school experiences with computers and other technologies.

The presence of computers in his classroom has made a substantial difference in the way Chris teaches. He observes that some of the programs he uses, such as *Printshop*, have led him into content areas he wouldn't otherwise have explored. His adaptation and invention of software programs for special students has also contributed to the changes in his teaching, prompting him to concentrate on students' control over their own environment and their own learning. Like many teachers he has "moved away from drill and practice and educational games toward applications."

According to Chris, teaching with a computer is both easier and more difficult. "The computer, in and of itself, creates different sets of problems." "From a logistical standpoint it can be more difficult, because there are so many factors you have to be concerned about. The first time I use new software it takes forever to figure out the kinks, but then, the next time, it's that much easier." On the other hand, "it's easier in that you might not have to do quite as much motivating; good programs provide structure, so that once you get a student interacting with them, your role becomes more that of an observer or an involved participant rather than that of the authority figure. The teacher can be a learner right alongside the student instead of being the presenter of information." He finds that sometimes this shift, which allows teachers to "show their humanness," is "the magic key that turns on students' willingness to try more things in the classroom."

His knowledge of computers has also affected Chris's relationship with his colleagues. He remembers that shortly after he introduced computers into his classroom, other teachers in school dubbed him the "resident expert." When people come to him for advice or training, he enjoys helping them and feels they appreciate his efforts on their behalf. In this way, the computer has heightened his professional status and opened opportunities for collaboration with other teachers.

In addition to these intangible fruits of technology use, Chris reports several ways that he and other teachers can convert their skills into professional gain. Since payscales are tied, in part, to the number of college credits a teacher accumulates, a teacher can obtain a salary increase by completing computer classes in accredited programs. The district will also pay for teachers to attend conferences and even provide them with "mini-sabbaticals" if important professional meetings conflict with teaching obligations. A teacher with a thorough background in computers might also be hired as an instructor in the district's summer training program. And finally, with the advent of a new merit pay system in the district, Chris expects that many teachers will advertise their computer training and skills as evidence of continuing professional development.

Chris hopes his expertise with computers will lead to professional advancement for himself. Recently, the district initiated a three-year plan for increasing hardware and software availability and providing more sophisticated on-site support services. The district office is creating a new support position for LD computer use as part of this technology plan, and Chris has applied for the job. In it, he would work with LD teachers throughout the district as well as with district personnel. His reasons for applying are clear: "I was looking for a change, looking for something fresh, looking for a way to be learning while teaching." He views the new post as an excellent place from which to promote teacher involvement in the development and integration of computer technology in education. He believes that in the absence of on-site specialists there have to be central office personnel "who are accessible, who have the time to attend to the concerns of the classroom teacher." Chris is optimistic about the potential of educational technologies and wants to help other teachers join in the promise: "Once the hardware's in place and the software becomes available, if we put it in the hands of teachers who have a little bit of background and a little bit of creativity, the possibilities are almost endless."

CAROLYN HEMENWAY: TEACHING COMPUTER SCIENCE AND COMPUTER LITERACY

As a high school teacher of computer science and computer literacy, composite character Carolyn Hemenway highlights the question of special computer courses versus integration of computers into the regular curriculum. Her job is to teach courses that satisfy the state-mandated computer literacy requirement, yet she believes that computers ought to be integrated much more into the teaching of subject matter. She does what she can by incorporating content from the regular curriculum into the assignments and projects she gives her classes. Carolyn finds that teaching in a computer lab enables her to work more with individuals and small groups and fosters more interaction and collaboration among students. This changing classroom organization creates some pedagogical dilemmas and some classroom management issues, however. Self-taught at the beginning, later schooled in university computer courses, and eventually a teacher trainer herself, Carolyn has an informed perspective on what these different training opportunities offer. As a former math teacher who chose the computer science career path, she also understands the new roles and rewards that computer expertise can open for teachers. One of her main concerns is equitable distribution of computer resources across the district.

Carolyn Hemenway teaches in a downtown high school with a heavy minority enrollment. She taught algebra and trigonometry at another school in the same large southern city for 12 years before taking her current job as a computer science teacher three years ago. Her classroom is a computer lab with 18 Apple IIs which she uses every day for the majority of each period.

Like many states, Carolyn's has a computer literacy requirement for high school graduation. Her job is to teach the two courses -- computer literacy and computer science -- that satisfy that requirement. Indeed, her current position was created as a direct result of the passage of that requirement. Nevertheless, Carolyn hopes that eventually computers will be integrated more fully into subject matter instruction and that students will acquire computer literacy in that context. She believes all students should learn at least the basics -- wordprocessing, spreadsheets, databases -- and that the regular curriculum should provide opportunities for teachers and students to use these tools to enhance the coverage of subject matter. A few math and science teachers are already attempting this, but there's been no general policy to use computers to enhance the overall curriculum and Carolyn is realistic about the prospects. For one thing, the school would need many more computers than it currently has, and the new equipment would need to be located in classrooms as well as in labs. For math and science, good software is often unavailable, and even if that problem were solved, teachers would need substantial training to mesh the software effectively with the curriculum they are responsible for teaching. Carolyn is not holding her breath because right now the school budget is so tight that it's tough to get any new equipment or even to maintain what they have.

In the meantime, Carolyn tries to integrate what she does in computer science and computer literacy with what students are doing in their other courses. She has the ninth-grade science text on a laser disk and tries to integrate wordprocessing instruction with the science modules, for example. A database, she points out, "has to be about something," so she might choose a topic related to, say, the social studies curriculum. This has led her to learn a lot about new content areas and to have more contact with subject matter teachers. In a sense, Carolyn believes that computers prod us to redefine what we want students to learn, and how.

Teaching with computers has changed the way Carolyn organizes her classroom and thinks about teacher-student and student-to-student relationships. When introducing a new concept or skill, she usually keeps students together for a whole-class demonstration at the lab's large-screen monitor. Some students pick up quickly on the new material and feel ready to go to the machines to start working on their own, while others stay for a second explanation or demonstration. If some students remain confused after several explanations, Carolyn pairs them with those who seem to be working successfully. Then she circulates around the room, talking and answering questions. Feeling sometimes like a coach and sometimes like a referee, she gets to know students better with this close contact and, with more information about them and their learning, she feels better able to plan for and meet their needs. She says she has always been close to her students and communicated well with them, but the computer enhances that rapport. "When you have to go around to kids individually while they're sitting at a machine and lean over to them and talk to them that up-close, some physical barriers are broken down, and some mental and emotional ones as well." She views this as an advantage but recognizes that "teachers who do not want to break down those barriers are not going to want to use computers."

Though Carolyn is enthusiastic about this change in classroom organization, she is frank about the dilemmas and problems it creates. She finds she has to be careful for the few students who tend to become dependent, always deferring to their partners and asking others to help them write and debug their program. "I haven't figured out how to solve that one yet," she confesses. "It's subtle." She also finds that teaching with computers creates some classroom management hassles, keeping track of all the equipment, manuals, disks, and so on. She thinks teachers in training should get a lot more classroom experience with the potentially overwhelming logistics of getting a whole class booted up at once, dealing with disastrously timed equipment failures, and so on. Handling these problems soon becomes second nature, but until it does, they can be nightmares and make a teacher ineffective.

Carolyn started tinkering with computers in the late 1960s, when as a self-confessed "gadget freak," she ordered one by mail and taught herself to use it. She enjoyed experimenting on her own, figuring things out as she went along. She used the manuals, bought lots of computer magazines, and "called around for help" to fill the gaps. Before long, a computer company in town began to offer courses, and she arranged to take one. She also took several courses at the state university, so when the state established a computer science and computer literacy requirement in 1983, she was one of the few people in the system qualified to teach those courses.

Her school district offers workshops and courses for teachers after school and during the summers. These are usually given in the district computer lab, and Carolyn rates them highly. Participants get a lot of hands-on time on the computers and good relaxed instruction. All the training is free or for a nominal fee. Teachers who want to receive graduate credit can pay an additional charge to do so. Even without graduate credit, teachers get in-service credits that count toward salary increments. Carolyn believes that truly useful learning occurs during these workshops and during informal exchanges among those who attend them; for example, at one recent workshop, she learned about adaptive equipment that has helped her teach a handicapped student to use the keyboard more accurately. She points out the edge these district lab courses have over many university offerings: "University professors typically don't know what's going on in the classroom and their courses reflect that inexperience. So they do what they can, which is to teach you about the technical details of something."

Carolyn now does some training herself. She provides informal help to teachers in her building, and from time to time she teaches the district's computer literacy course for teachers. She enjoys teaching teachers almost as much as teaching students because she likes trying to help them overcome their fears and worries about technology. "As I define it, the bigger part of the problem of bringing technology to schools is a psychological one. There are very few mechanisms in schools to disseminate skills because historically teachers haven't really developed many more skills than they had when they arrived. So the real problem is not the technology itself, but to build the infrastructure for disseminating these skills to teachers who aren't used to asking for or giving help."

The introduction of computers into the district has led to new roles and rewards for others besides Carolyn. Most of her fellow computer science and computer literacy teachers also have math backgrounds and were formerly math teachers, though she knows of one who crossed over from English and another from drama. At least two other teachers avoided layoffs because they had computer skills and could be relocated to positions that involved computers; one moved to a district lab position and another was appointed assistant principal, a job requiring use of computers for scheduling classes and keeping school records.

The district pays Carolyn $2,000 a year beyond her regular teacher's salary to oversee equipment, purchase supplies, and help other teachers who request it. She knows that some colleagues are envious of that stipend, especially since no money is available to pay teachers to attend conferences or buy equipment. She knows, however, that she earns every penny of her extra pay and feels that it offsets some of the hidden disadvantages of her position. The district is reluctant, for example, to give computer teachers release time because they are in charge of so much expensive equipment, and substitutes are scarce. In addition, funding for supplies is adequate, so by the end of the year she finds herself dipping into her own pocket to keep the lab running.

Carolyn objects to what she believes is the inequitable distribution of computers and computer resources in her district. She knows that some schools -- especially the district's math and science magnet schools -- get more resources than schools like hers, which take all students and serve many at-risk kids from disadvantaged backgrounds.

The district doesn't blatantly give more money and attention to the magnet schools. The inequities are more subtle and indirect; for instance, the magnet schools are hooked into school-business partnerships that bring in all sorts of extra equipment and training for teachers. Sometimes this is because magnet school principals have taken the initiative to seek outside funding. Whatever the reason, the result is that kids who are higher achievers and from middle- to upper middle-class backgrounds get more access to computers.

Carolyn feels strongly about equity because she believes "computers can help improve schools and reach kids with learning styles that could not be reached by the traditional teacher-centered model." She is realistic, though, about money and accountability. She points out that "it's very hard to know whether we're getting a satisfactory return on the money we pour into equipment and teacher training." She also sees knotty management decisions about who gets what, and how to keep hardware and software up to date. The financial demands go beyond the initial outlay to include expensive upgrading and updating as well. She thinks it would be a shame if all those resources served only the cream of the crop or resulted in nothing more than mechanized drill and practice.

MARILYN GORDON: INTEGRATING COMPUTERS INTO THE SECONDARY MATH CURRICULUM

Composite character Marilyn Gordon is a veteran secondary school math teacher who uses computers extensively to teach subject matter. The first in her school to use computers in teaching, she started with drill-and-practice software but quickly moved toward more open-ended uses that allow students to learn through inquiry and problem solving. By promoting this kind of learning, she feels computers enable her to teach the way she has always wanted to and to do things that can't be done with other media. Marilyn uses the computer for whole-class demonstrations as well as for small group work in the lab. She thinks the computer's strengths for teaching subject matter are that it can make abstract concepts more concrete, that it enables students to construct and manipulate mathematical "objects," and that it facilitates group problem solving and sharing of ideas. She believes that despite these advantages most subject matter teachers will not incorporate technology until they have easier access to hardware and software.

Marilyn Gordon has been teaching mathematics for 21 years in a suburban high school of 1,100 students in the Midwest. She holds a bachelors degree in math and has 70 hours of credit at the graduate level.

Marilyn's own learning about computers and her classroom use of them has evolved considerably since she first became interested in technology about six years ago. After reading several articles in trade magazines, she took some programming courses and bought a computer, expecting at first that she would create her own instructional software. She quickly realized, however, that she did not want to be a programmer. Instead, she began to use commercial software, initially drill-and-practice programs designed for math classes.

As the first person in her school to use a computer in the classroom, Marilyn was selected in 1982 to serve on a team of one science and two math teachers to visit schools within and outside the district to see how they used computers. Most of the schools they toured taught students computer literacy, which included such things as the history of computers and keyboarding skills. By that time Marilyn was becoming convinced that computers should be integrated into the curriculum and not viewed as a separate subject, but few of her colleagues agreed with her. When a new curriculum coordinator was hired, his first job was, "to make me think like everybody else." Instead, she wound up persuading him of her viewpoint.

Now, Marilyn eschews drill-and-practice software which she refers to as "glorified electronic worksheets." If and when Artificial Intelligence plays a larger role in the design of this kind of software, she believes it may improve; meanwhile, she wants her students to learn concepts through inquiry and problem solving. She prefers to give assignments in which she can "create some sort of openendedness." For example, she now uses the *Geometric Supposer*, which allows students to make and test hypotheses.

Enthusiastic as she is, however, about open-ended problems and student exploration, Marilyn has learned that she has to pose such problems carefully and give students some direction. "It's inefficient to let them just play around at the computer. . . . I think you can guarantee that students are going to see important mathematical ideas more easily if you structure lessons toward specific objectives."

Marilyn would like to have professional time to develop other classroom uses of the computer. She has lots of ideas but needs time to sit down and organize them. The science department in her school, which participates in a project sponsored by the National Science Teachers' Association, recently has started to use Microcomputer-Based Laboratories (MBLs), hardware and software packages that allow teachers and students to attach a variety of probes to the computer, such as thermometers or motion and light meters, to collect data, to analyze these data in real time, and to present them graphically on the screen. These packages allow students to get a sense of what it is like to be a scientist in a lab. They are wonderful tools for teaching subject matter, but teachers, she feels, need time to figure out how to use such hardware and software in their classrooms; failing that, they need someone to screen software, then show them how to integrate it into their instruction. In addition, some teachers need help in resolving classroom management issues such as planning what to do with the rest of the class while a few students are at the one or two computers generally available.

Marilyn is bullish about the potential of educational technology because she finds it helps her teach better. She believes computers have three major advantages over traditional media of instruction. First, the computer's graphical or pictorial capabilities help make abstract ideas more concrete. For example, "I can't show on a blackboard a thousand balls dropping through a triangular grid," she says, "so I use computers a lot for simulations."

Second, some uses of the computer require students to construct or to manipulate things in order to write a program or test a hypothesis. With the *Geometric Supposer* her students can construct and measure lots of geometric figures so they can form and test their own hypotheses about geometric relationships and laws. She also uses the computer to "teach graphing and equations through a real discovery method. I can pose questions about graphing equations, about slopes of a line, and students can investigate and test things out. The computer can do that right away -- you know y=2x, y=3x, y=4x. They see the line move up and down and they make generalizations. You can do that without a computer, but not as fast. So you can really cover more. It leads them to a discovery in a 45-minute period, which they could not do without a computer." She firmly believes that if other physical manipulatives could be put into computer graphics, a lot of concepts could be taught effectively on the computer.

Third, computer use facilitates the sharing of ideas and group problem solving among students; "pairing kids [at the computer] is better than letting kids work alone," Marilyn believes, "because they talk to each other a lot." By allowing her to use a less teacher-centered, more discovery-oriented approach, computers help her give students much of "what attracted her to mathematics in the first place." "I know that before computers were widely used," she says,"teachers tried to get students to work in small groups -- you know, the discovery approach and all that -- and I think it has its place.

Computers fit in very well with that type of process." After she teaches a new concept to the whole class, she often divides students into small groups so they can be more actively involved in testing their ideas.

Computers have spawned other changes in Marilyn's teaching and in her relationships with students. She views the computer as a new tool and is comfortable admitting to students that they might know more about it than she does. She says, "When I first started teaching mathematics I felt pretty secure about what I was teaching. Except for an occasional word problem that might run amok, I generally felt the students could rely on me to know what I was doing. Now, I constantly run into situations where I have to answer, 'Well, let's go check that out,' or 'I really don't know.' At first that bothered me, but now I'm relaxed about it because there is so much to learn, and it's quite common among my colleagues at other schools and for myself, too, to hear teachers say, 'Well, I'm going to learn C this year along with my students,' or 'A student is going to bring in a piece of software and show me what it does.' So I think students are now seeing teachers much more as learners. They see that teachers are learning all kinds of things and that kids are often showing teachers new things." "It's more difficult in the sense that you don't have all the nice control...that goes on in book learning," but as teachers become more comfortable with what they are doing and why, teaching with the computer becomes easier.

Marilyn feels that ease of access is a major determiner of how much teachers will use computers. She is permanently assigned one computer with a large screen monitor which she uses as a demonstration device, but she generally manages to have two other computers with one printer in her classroom. These additional computers are on rolling carts and float among rooms in the math department. She sets these up so that students can use the computers for problem solving during class. After introducing math concepts she gives her students problems to review on the computer. While some students are using the computer, others work on individual or small group assignments. She believes that if teachers always have to go to the trouble of going to the lab, computers will be used less often. She prefers the convenience of having machines in the classroom where they can be used whenever she needs them. In addition, if she does not want or need to use the computer for an entire lab period, she hesitates to tie up scarce resources needlessly. She is currently writing a proposal for a grant from a local school foundation to get funds so that each math class in her school will have a large screen monitor.

Having to run around finding computers and getting them into the classroom was a problem Marilyn faced three or four years ago. Many times she was tempted to throw up her hands and say, "Forget it! It's not worth it if I only need it for a short time and I have to see four teachers to get their permission!" Now, seeing the the way technology has benefited her and her students, she's glad she persisted.

ALAN WHITE: TRAINING TEACHERS AT THE DISTRICT LEVEL

As a district level teacher trainer, composite character Alan White has a valuable perspective on training issues raised by classorom teachers at all levels. He sees the question of voluntary versus mandatory training as a thin line between supportively prodding teachers and engendering resentment. He recognizes that requiring training will only create frustration if teachers have no immediate opporunity to use it. He believes that good training treats teachers as professionals, helps them overcome anxieties about computers, provides follow-up, helps with access to hardware and software, and -- perhaps most important -- helps teachers see how to integrate computers into their curriculum. In developing his training approach, he has evolved several strategies -- such as having teachers come to the lab with their students, allowing them access to computers without direct requirements as to how they will use them, and showing them how computers can help with teaching- related tasks such as grading -- to draw them in. Alan believes that tapping the educational potential of technologies requires layers of support, including a supportive principal, buildng-level resource people, district-level training with clear priorities, and interest from the local and business communities.

Alan White is a special projects teacher in a large urban school district in the Midwest. A fifth grade math teacher for 18 years, Alan was asked in 1983 to join the Office of Instructional Technology to develop computer-related training courses for the district's teachers. He works closely with the subject area coordinators in the Office of Curriculum Services, who organize departmental in-service courses.

Alan believes training is most successful when voluntary. Experience has shown him that people learn best when they can select courses that interest them and attend without coercion. At the same time, he realizes that the question of voluntary versus mandatory training is not so simple. From an IBM pilot project he worked on, he learned that requiring training makes little sense if teachers have neither home nor school access to the hardware and software used in training. "You just fuel their frustration and cynicism," he warns. On the other hand, teachers often don't volunteer precisely because of the fears or worries a good course can help them overcome. Some teachers are afraid of technology -- afraid, for example, of breaking the machine or appearing incompetent. Others, though curious, have been put off by previous frustrating experiences. Still others are less anxious about computers than reluctant to learn new ways of teaching, a response particularly prevalent among older teachers, Alan reports. They seem to feel, "I'll be gone in a couple of years, so there's no point learning something new." Alan's job is to help these teachers overcome their fears, and he's proud of his record.

Good training, in Alan's view, requires a few essentials. First, teachers must be treated as professionals, which, he believes, means paying them for their time as well as giving credit for certification or toward a degree. Although money is rarely the crucial motivator, credit and reimbursement show that administrators value the

teachers and the training. Second, good training should alleviate computer anxiety, which Alan defines as "the real frustration and intimidation that occur when you don't know which key to press or which button to use. If someone can't tell you that, you just have to stop your project. Even though you know what you want to do, you don't know how to make the machine do it for you. You feel like you're not very smart."

He believes that to have significant impact, training must help teachers see how technology can be integreated into the traditional curriculum. They must become convinced that computers are not just another imposition but can help them "teach better." His district originally offered two general computer literacy courses, one for elementary and one for secondary school teachers. As more software became available, both courses became applications oriented. Teachers could learn to use wordprocessing programs, databases, and spreadsheets and try out a variety of software in their subject areas. Now the district has a "cafeteria" approach to training, offering a whole "menu" of one-credit courses, each lasting about five weeks, from which teachers can select what is most useful to them. This modular approach has been very well received. For next year Alan is designing a "software sampler" course in secondary language arts. Teachers will evaluate software for five weeks, then choose a package that fits their curriculum. Their final project will be to create a lesson plan that integrates the program into a regular lesson. The lessons will then be shared, so that teachers will take away a number of classroom applications to use with their students.

For reluctant teachers, Alan has developed some additional strategies. Sometimes he focuses on the computer as a "teacher productivity tool," less for instruction than for work outside class. He encourages those who do not feel ready to start teaching with computers to use technology for such tasks as grading, preparing worksheets and quizzes, and writing recommendations. When possible, he likes to give such teachers access to computers without any initial expectation that they will use them in teaching. If they're not pressured toward instructional uses, but are shown how technology can ease some aspects of their job, Alan finds their fears and skepticism wither. He thinks the ideal arrangement is to let novice teachers take machines home for a few weeks, to practice at their own pace. It "lets them know we care," he says. More important, teachers "will come back to school with 20 more ideas" than they had before they took the computers home.

In contrast to what happens in many schools, Alan has succeeded in bringing teachers into the lab with their students. He discovered the power of this strategy during a special project to raise the geometry scores of lower achieving students. The principal insisted on the teachers' presence while Alan taught the lab. Some of them used the occasion to learn wordprocessing or Logo; others helped him attend to students' needs and answer their questions as they worked at the computers. For many teachers, coming to the lab made computers less mysterious and intimidating. "If something happened," Alan recalls, "I was right there to say, 'No, you press this button,' and on they went instead of becoming frustrated and giving up. They also saw how well their kids took to it." Since then, he has used the lab to entice teachers into using computers in their classrooms. He invites them to bring their classes and offers to demonstrate how to use a particular program and tie it into the curriculum. He is gratified that some of what he does seems to rub off on the teachers. Although most math teachers like a

very quiet classroom, those who bring their students to the lab "do not seem to object to the amount of conversation I allow." As a result, Alan is "getting teachers to open up a little bit" and tolerate more lively classroom discussion and team problem solving.

Alan tells teachers honestly that using computers can making teaching more difficult at first. "It provides the teacher a greater opportunity to individualize, but just having that capacity does not make it easy -- as a matter of fact, it makes it harder." Managing a classroom while assessing what students are doing on computers complicates instruction. "Individualization is a very difficult thing to manage," he says, remembering his first forays into classroom computer use. "It took me two months to understand what was going on, then many more to get good at it, to learn all the programs and all the intimate details and intricacies of how that room worked. It took me a good year to get comfortable."

Alan believes that nurturing the potential of educational technologies requires layers of support within a district. Traveling from school to school, he has seen the importance of strong support from principals, who, in many ways, are the key to providing teachers with the equipment they need, a teaching schedule they can cope with, and support for curriculum development and for the way they want to work with students. If principals can provide these conditions and also give teachers instructional freedom -- so long as they follow district guidelines and meet district objectives -- teachers can produce truly exciting results.

While the principal's support is important, Alan emphasizes that teachers also need other building-level support, and here he feels his own district falls short. Inadequate building-level support staff has made the telephone extremely important in helping teachers, but phone support is not enough. Often teachers need help immediately and are not well served when put on hold or asked to leave a message. According to Alan, the ideal solution would be to have a cadre of resource people within each building who could answer questions and solve technical problems. In the meantime, the district has hired several resource people, each responsible for a portion of the schools in the district. Some principals have asked the media aides in their building to serve as computer consultants to teachers.

The district has also organized a computer lab, open two evenings a week, and Alan or someone else is always available. Teachers come for help with a problem or to ask a question. They can also preview software and plan classroom activities. In addition, Alan and others in the Technology office are trying to build networks among teachers who use computers in teaching. Some buildings are very large, he points out, and a foreign language teacher at one end may not know that a social studies teacher down at the other is also using a computer and could probably answer some questions.

In Alan's district the computer program enjoys strong support from the local community. Several PTAs, for whom he has often given talks about computers, have contributed funds to their schools' computer programs, enabling the purchase of a color printer, new software, and other supplies. In addition, a business community grant provided the money for computers and printers for a special wordprocessing project.

DISCUSSION

The profiles condense the experiences of a wide variety of teachers into a limited set of composite images, each conveying representative experiences within the context of typical school settings. This section aims to complement the profiles by summarizing patterns that emerged across the entire set of teachers and discussing them in light of related research. We have organized this section around the following topics: how teachers use computers; influences on teachers' decisions about teaching with technology; the effects of new technologies on teachers; and the resources and supports that teachers want.

HOW TEACHERS USE COMPUTERS

The most common use teachers in our sample made of computers was outside their classrooms. The majority made some use of computers either for professional or personal purposes at home, at school, or in connection with other activities, such as coaching athletic teams or doing volunteer work. Many found wordprocessors, databases, and other application software, such as grading packages, to be a great help in preparing lessons and teaching materials and in keeping records of student work. One obvious implication of this finding is that merely introducing teachers to computer technology does not automatically help them incorporate it into classroom practice.

Within the classroom, we distinguished two general ways of using computer technology : (1) as an object of study and (2) as a tool for teaching and learning subject matter in the regular curriculum. These two kinds of use involve rather different implementation requirements and effects on teachers in regular school programs.

The first category includes programming courses and courses intended to teach students about computers, such as computer literacy courses not connected to students' work in their regular academic program. Such courses usually constitute an addition to the traditional offerings in the schools, without significantly affecting curriculum or practice in the regular program. When taught by "computer" teachers, these courses need not require the regular faculty to have any contact with the technology. Indeed, several teachers we interviewed pointed out that computer literacy courses often monopolized the available computers in the school, thereby discouraging the integration of this resource into the regular curriculum.

Courses that make the computer an object of study have been very popular in American chools. In 1985, Becker's survey of computer use in the schools revealed that computer programming courses were still the most common use of computers in secondary schools. A review conducted by *Electronic Learning* (1987) indicated that nearly 80 percent of all states officially recommended that schools provide students with exposure to computers. Eleven states plus the District of Columbia required all students to take a computer literacy course. More often, however, states recommended integrating computers into the traditional curriculum.

In our sample, more teachers used computers as an educational tool within the regular school curriculum than used them as an object of study in special courses.

Further, we found teachers at least as likely to use the computer to support students in open-ended problem solving activities as they were to use it for drill and practice. This pattern of response is different from results reported by Reed (1986) based on a recent survey of teachers who favored using computers to teach computer awareness and literacy. It also differs from Becker's (1986) most recent survey, but is consistent with the overall trends he has identified in teachers' uses of computers. The survey he conducted in 1985 indicated that the majority of elementary teachers still found CAI the best use of computers and that the majority of secondary teachers found programming and computer literacy the best use. At the same time, he noted that as teachers become more experienced in using technology they tend to shift from these kinds of uses toward viewing the computer as a tool to support the regular school curriculum. Overall, his 1985 survey indicated a movement in this direction when compared with his 1983 survey data.

We surmise that our findings are consistent with the progression Becker has identified toward using the computer throughout the curriculum and using it more to support open-ended problem solving than drill and practice on tasks with one right answer. This conclusion is supported a comparison of our interviewees' opinions about how they thought computers *ought to be used* with descriptions of their *current actual use*. More teachers in our study thought computers ought to be used as a tool for teaching and learning throughout the curriculum than actually used them this way. Also, more teachers thought the computer ought to be used to support inquiry learning (to "take emphasis off algorithmic learning and allow the teacher to develop concepts," as one teacher said) rather than for drill and practice.

If the responses of our sample reflect a widespread trend, we must pay particular attention to the requirements and effects of integrating computer technology across the curricular subject areas. Clearly, the materials and teacher supports necessary to accomplish this agenda are different from those needed to help computer specialists teach about the computer in courses that remain essentially isolated from the mainstream school program.

INFLUENCES ON TEACHERS' DECISIONS ABOUT TEACHING WITH TECHNOLOGY

Three general factors were seen to influence teachers' decisions regarding the use of technology in their classrooms. These are: (1) teachers' knowledge of appropriate uses of computers, (2) access to necessary resources and support, and (3) incentives that favor or discourage computer use in the classroom. Untangling these factors to explain any single teacher's decisions would be difficult, but recognizing the nature of their influence indicates points of leverage for those who wish to change teachers' minds and behaviors.

Teachers' Knowledge and Beliefs

Teachers evaluate most proposed innovations on the basis of their potential educational benefits (Mohlman et al., 1982) in relation to their costs. Doyle and Ponder (1977) describe the "practicality ethic" which guides teachers in making these decisions.

They explain that teachers consider three aspects of practicality: the extent to which the proposed innovation is spelled out in instrumental terms tied to classroom practice; the congruence between the new approach and the teacher's customary approach and situation; and cost conceptualized as a ratio between the amount of return and the amount of investment.

While these practical considerations appear to be at work in teachers' decisions about new technologies, computer-specific reactions also hold sway. Some educators appear to view use of computers as an end in itself, rather than assessing computers as one possible means to educational ends. Teachers we surveyed frequently explained their use of computers in the classroom on the basis of a responsibility for preparing students to live in a world where computers will be commonplace. A similar mindset can be discerned in districts where more attention is paid to the acquisition and required use of computer hardware than is given to the development, support, and assessment of educational applications of these tools.

Teachers with more experience using computers in the classroom were more likely to be motivated by the educational potential of computers than by a desire to prepare students for a technological future. As one teacher said, "I wanted to be part of the 'wave of the future' and got a computer at home, but now I'm more impressed by its impact on teaching and learning." A third motivation mentioned frequently, but less often than the first two, was teachers' own interests, such as a fascination with computers, a desire to motivate students, or a wish to save time preparing materials. In summary, it seems likely that an interest in the technology itself might draw teachers into using computers, but that subsequent personal or educational payoff will be necessary to sustain their interest.

Teachers' knowledge and beliefs can also disincline them toward work with new technologies. The most frequently mentioned barrier was a lack of specific "visions of possibilities" (Sarason, 1971), that is, an inability to see how the potential contribution of specific innovations to their particular practice would outweigh the costs involved. Several teachers knew of no software that could significantly improve education in their area. Others had seen interesting uses of computers but felt they could not introduce any new activities into their courses and still "cover the required curriculum." Some teachers expressed fears about negative social and educational effects of computer technolgy in the classroom. They worried that it was too complicated, likely to make students into automatons or to encourage teachers to take unfair advantage of "electronic babysitters." These arguments are often contradicted by teacher reports (McDonald, 1985) as well as by research in classrooms (Sheingold, et al., 1984) which suggest that some ways of teaching with computers actually increase students' interactions with each other and their teachers.

Several teachers in our study reported that their fears about the negative effects of computers dissipated in the face of positive examples. Once they saw specific ways of teaching with technology that yielded clear educational benefits, their objections diminished. A key implication of these findings is that teachers vary in their curricular goals, their assessements of their students' needs, and their preferred

teaching approach. No single way of using technology will fit with all teachers' aims, interests, and needs.

Access To Resources and Support

Teachers' decisions about educational technology are significantly affected by the extent to which they have well coordinated access to resources and support. Necessary resources include software, hardware, courseware (teaching and learning materials), and the training and support necessary to incorporate new approaches into classroom practice (Becker, 1985; Linn and Fisher, 1984; Sturdivant, 1983; Tetenbaum and Mulkeen, 1984.)

Asked about impediments to their employment of technology, teachers we interviewed most often mentioned lack of access to appropriate software and hardware. Teachers who cited software as a significant barrier noted a host of problems, from not knowing what was available, to finding that available software was inappropriate for their classes, to struggling with a single disk when what they needed were multiple disks.

On the matter of hardware, teachers emphasized that the mere presence of computers in the school does not guarantee sufficiently convenient access. The location of the computers, as well as the process for scheduling their use, shapes whether and how teachers might use the hardware. A single computer in the classroom may serve effectively as a learning station for small groups of students in rotation; equipped with a large monitor, the same computer can also serve as an "electronic chalkboard" to enrich interactive demonstration lessons. A laboratory of computers is suited to other uses. Equipped with a sufficient number of machines (perhaps one for every two or three students, depending on the teacher's preferred mode of grouping), a lab supports lessons that engage the entire class in computer-based activities at once. This potential is lost, however, if the lab is too remote from the regular class or too difficult to schedule. Particular configurations of hardware support certain teaching styles and activities; thus, convenient access to hardware must be viewed in terms of teachers' particular preferences.

Many teachers in our study noted that special programs with technology components, such as computer literacy courses or Chapter 1 classes, had priority or even exclusive access to the computer lab. As one teacher said, "A lot of talent in the system is being wasted because the computers have been put under the lock and key of one person."

The other most frequently mentioned barrier to using educational technology was a lack of access to appropriate preparation and support. Nearly all teachers had access to some form of training with computers, but several conditions made training fall short of sufficiency. The most frequent complaints were that the training did not prepare teachers to integrate the computer into their teaching, that it did not include enough time for them to become comfortable with the software, that it did not include follow-up support to help them "troubleshoot" during the early implementation stages, and that the training experience was not tailored to the teachers' needs.

Few teachers specifically mentioned the lack of courseware as an important impediment, but the issue is implied by those who said they did not know how to integrate the technology into their courses. A few more experienced teachers in our study confirmed what other research (Cline et al., 1986; Hawkins & Sheingold, 1986) has shown, namely, that the "orchestration" of integrating new technologies into the traditional curriculum is not simple. Teachers need lesson plans, teaching aids, problem sets, and worksheets in order to carry out lessons with computer technology. Many teachers want to adapt such materials to their own circumstances, but they do not have time to invent them all from the beginning. A lack of appropriate courseware may preclude computer use, even when all other implementation requirements are met.

Finally, in order to be truly useful, provision of resources must be synchronized. Access to hardware without appropriate software or training is as useless as training without subsequent access to the technology. Asynchrony in access was a common problem. Some teachers, like "Laurie Adler", found a computer in their room before they had any opportunity to learn how to use it; others, like "Abby Miller," have been caught between state mandates that require computer literacy courses and local spending caps that limit computer hardware purchases.

External Mandates and Special Opportunities

Teachers' uses of computers are significantly shaped by extrinsic constraints and rewards (Amaral, 1983; Jackson & Deal, 1985; Rogers et al., 1985). These may include formal policies and mandates as well as more subtle yet powerful influences such as local priorities and norms.

Every site in our study was subject to one or more state or local policies regarding the uses of computers in the schools. For example, several teachers mentioned that Title I funds had been used to purchase computer hardware whose use was restricted to participants in that program. Several sites operated under a requirement (generated either by the local school district or the state) that students be taught computer literacy. A few had recognized that such mandates tended to isolate technological resources from mainstream education and had attempted to remedy this situation. In Washington, D.C., for instance, a five-year plan has recently been adopted to promote integration of computers into the regular curriculum. The plan includes incentives (hardware, software, and training opportunities) as well as requirements (a course on educational technology will required for teacher certification). This emphasis on integrating computers into the traditional curriculum is consistent with the trend in many state departments of education (*Electronic Learning*, October, 1987).

Local values, norms, and priorities influence whether and how teachers use computers. An "innovational champion" (Parker, L., 1971) who promotes the use of technology may stimulate and sustain the interest of otherwise reluctant teachers. Building principals, who are in a position to control the flow of resources such as money, staff development time, and course assignments, were often mentioned as key actors in supporting or discouraging computer use. Similarly, curriculum coordinators and others who make decisions about "coverage requirements" and assessment procedures influence teachers' decisions about whether and how to incorporate new

technologies into their practice. Local values (e.g., an emphasis on instruction in basic academic skills versus a priority on teaching students to become proficient problem solvers) shape teachers' goals and practice (Anyon, 1981) and their preferred ways of using technology (Wiske, Shepard, & Niguidula, 1987).

Whether computer-related mandates and pressures encourage truly educational uses of new technologies is debatable. The outcome depends partly on whether associated resources and requirements focus on technology as an end in itself rather than emphasizing improvement in education. That they exert a powerful influence on teachers' decisions is clear.

EFFECTS OF NEW TECHNOLOGIES ON TEACHERS

In thinking about the effects of new technologies on teachers, it is important to recall the image of the computer as Rorschach card (Amaral, 1983) onto which educators can project myriad purposes. The range of possible software allows the computer to serve as an educational tool for virtually any subject matter, any educational philosophy, any teaching approach. Even a single piece of software may be suitable to a range of educational purposes, serving as a provocative learning station for single students in one case, a tool for interactive demonstrations led by the teacher for the whole class in another case, and the focus of collaborative problem solving for a small group of students in yet a third case. Given this variety, asking what effects computers have on teachers seems as broad as asking what effects books have on teachers. A clear message from this study is that the impact of computer technology on teachers cannot be considered narrowly but must acknowledge a wide range of technologies, teachers, and school contexts.

We asked teachers to reflect on several ways we thought computer technology might have influenced their lives: curriculum, teaching style, the social structure and management of the classroom, and shifts in their roles as professionals. Despite the predictable variations in their responses, themes emerged in each area.

Curriculum

The relationship between computer-related activities and the existing school curriculum may vary from no connection whatsoever to impacts that vary in intensity. The new activities may be an add-on, may have a marginal effect, or may have a transforming effect on the regular program. The implementation challenges increase for teachers as they attempt to change the core curriculum (Cohen, 1987). Not surprisingly, many of the teachers we interviewed spoke of using computers for extracurricular activities, in courses outside the mainstream program, or in ways (such as occasional use of drill-and-practice software) that had only a marginal effect on the regular curriculum. The common pattern of teaching "computer" courses separate from the regular academic program also served to limit the impact of computer technology.

Other research (Lampert, 1987; Wiske, Shepard, & Niguidula, 1987) has shown that teachers are reluctant to attempt innovative approaches when stringent curriculum requirements are reinforced by standardized tests. They feel understandably

accountable to uphold their professional responsiblilities and to prepare their students to pass tests that constitute crucial gateways in their academic progress. Teachers who can participate in a renegotiation of curriculum and testing requirements are more likely to consider potentially transforming uses of computers (Wiske, Shepard, & Niguidula, 1987).

The physical location of computers in the schools and the ease of scheduling access to them affect the extent to which computers influence the curriculum. Interviewees like "Carolyn Hemenway" point out that teachers would be more likely to employ technology in their regular program if computers were located in their classrooms. Having to schedule the computer lab in advance and make arrangements to relocate the class consitute a logistical burden which teachers may feel is to heavy to justify.

Despite the greater difficulty of using computers in ways that significantly affect the standard curriculum, many teachers in our sample were attempting to do just that. Teachers like "Marilyn Gordon" find that computer technology enables them to present ideas in new ways. Previously abstract concepts can be represented and manipulated in more concrete form on the computer screen. Simulations help students visualize ideas and perform operations that would otherwise be impossible. With computers, she feels she can include new topics and teach traditional ones more thoroughly .

In several school districts, people like "Alan White" are searching for ways to build effective links between the previously isolated computer literacy courses and the mainstream educational program. By linking computer teachers with subject matter teachers, they hope eventually to integrate the new technology across the curriculum.

Teaching Style and Social Organization in the Classroom

Very often, new tools are adapted to teachers' existing style (Berman & McLaughlin, 1974; Hawkins, 1985; Jackson, 1986). As one computer trainer said of teachers in her district, "They're still teaching the same things in basically the same ways that they have been teaching, and then on the side they're sticking computers in." This finding is not surprising given the stability of the curriculum and social organization of schools (Cohen, 1987; Goodlad, 1984; Sarason, 1971) and the relative unimportance of technology in comparison with human judgment in the overall craft of teaching (Heinich, 1985; House, 1979). What is surprising, and worthy of further attention, is the extent to which teachers report that teaching with computer technology has significantly affected their practice. We need to understand more about the circumstances surrounding such reports.

Teachers who thought the use of computers had shifted their teaching approach most often mentioned that computers had helped them vary the traditional picture of the teacher lecturing the whole class of students. "I used to throw information at people and expect them to memorize," said one teacher who thought she had changed her style. Teachers like "Carolyn Hemenway" reported that computer technology facilitated an approach in which students work on problems individually or in small groups while the teacher circulates among them, serving as a coach or facilitator of student learning. "Laurie Adler," "Chris Johnson," and "Marilyn Gordon" found that their ways of using

computers helped students move from an approach that focused on memorization of facts and algorithms to active inquiry with more open-ended problems. When computers enable students to work at their own speed and to figure out more for themselves, teachers can function more as facilitators of students' learning than as presenters of ready-made knowledge. "I've become more of an involved participant than an authority figure, a learner with students rather than a presenter of facts," said one teacher. This role may not be entirely comfortable or even desirable for teachers who enjoy directing a teacher-centered classroom or who work in a setting where teachers are expected to know and tell right answers.

Some teachers (Hawkins & Sheingold, 1986) note that by circulating among students working at computers, they notice more about the way their students are learning. As one teacher in our study said, "I learned a lot more about the individual learning needs of my students because I can watch them learn. Previously when I was in the teacher-centered mode I really couldn't watch them learn because I was busy delivering the curriculum. So my role has changed that way . . . being able to learn a lot more about my students because of computers."

Teachers who shift from what Goodlad (1984) calls "frontal teaching" often report that they have seen encouraging changes in students' roles. Students take more responsibility for their own learning and for helping each other learn, working together to solve problems. Some students who do not respond well to lecture-type lessons deal more positively with the interactive, visual medium of the computer. Thus, the introduction of computers may create new opportunities for learning and leadership in the classroom. These perceptions are very consistent with the findings of Hawkins and Sheingold (1986) who reported that the introduction of Logo in classrooms seemed to promote a "restructuring of expertise," including an increase in "peer expertise" recognized by students.

Amidst these enthusiastic reports of significant positive effects on classroom roles and responsibilities, we also heard from many teachers who thought computers had exerted little or no influence on classroom behavior. These reports tended to stem from two quite different circumstances. Teachers who used drill-and-practice or tutorial software usually found that the computer had no effect on their teaching. Such software is designed for use by individual students working independently from the teacher. Because computers used in this way require little involvement from teachers, it is not surprising that teachers find computers have little impact on their pedagogical approach.

The other reports of "little effect" tended to come from teachers who reported that they had always been committed to tailoring lessons for individual students or to "discovery learning" approaches. For many of these teachers computers seemed like a natural extension of their arsenal of teaching tools, "a vehicle that fits into the way I was already moving."

Classroom Management

Among teachers who have taught with computers, the consensus is nearly unanimous that, at least initially, most uses of computers make teaching more

difficult. It takes planning to incorporate computers into a lesson, to sort out the logistics of who will use equipment when and where, to make sure the necessary hardware and materials will be available, to design a fall-back lesson in case the technology malfunctions. Assessing student progress may be more difficult when students are tackling more open-ended sorts of problems, collaborating with other students, and turning in assignments that require more than a right/wrong grade (Hawkins & Sheingold, 1986). Although computers may facilitate the process of tailoring learning experiences to individual students' needs, the process is still difficult. As "Alan White" recalled, "It took me two months to understand what was going on, then a year to get good at it, to learn all the software programs and all the intimate details and intricacies of how the room worked. It took me a good year to be comfortable, but by the end of that time my room was pretty red-hot." Another teacher vividly conveyed the experience of working with students in the computer laboratory: "Days I spend in the lab, I wear tennis shoes."

Although teaching with computers may initially require more preparation, teachers also report that the technology eventually eases some aspects of classroom management. Students often find their work on the computer interesting so that teachers encounter fewer discipline problems. A few teachers reported that they use spreadsheets or special purpose grading programs to help with record keeping, and a great many of them said that applications software like wordprocessors and database managers have streamlined their work in preparing lessons and keeping records.

Effects On Teachers' Roles as Professionals

A large number of teachers found that their experience with computers added informal new dimensions to their roles as professionals outside the classroom (changes in teachers' roles inside the classroom were discusses earlier in the section about Teaching Style and Social Organization in the Classroom). They often serve as resident experts in their buildings, providing advice, encouragement, and assistance to their colleagues as they begin to use computers. Teachers like "Abby Miller" believe that such on-site mentors, willing to support a learn-as-you-go process, offered the best kind of training. Most teachers who had experienced such shifts in role said they enjoyed the admiration they received and were pleased to serve as advisors to their colleagues. Only a few of the teachers in our study complained of the extra work.

For some teachers these role transitions were accompanied by a formal change in position. "Carolyn Hemenway" experienced a common progression in role from subject matter teacher to computer literacy teacher (or to a combination of these roles). For others, the movement is to positions as computer coordinator or trainer serving teachers in one or more schools. Some teachers were able to move into new teaching or administrative positions requiring familiarity with computers when their former positions were eliminated by budget reductions.

Hardly any of the teachers in our sample thought new educational technologies would be the deciding factor in teachers' decisions to stay or leave the profession. Many acknowledged that using new technologies had refreshed them professionally, making teaching more interesting. Others acknowledged that computer expertise could enhance

their marketability outside the school. But most insisted that decisions about whether to leave the profession are primarily influenced by salary and perceived status and appreciation.

RESOURCES AND SUPPORT TEACHERS WANT

Given that our study was based on a single interview with each respondent, it does not give a clear picture of the evolution of teachers' desires over time. Nevertheless, the pattern of responses suggested that the teachers experienced a progression of concerns comparable to those described by other researchers (Hall & Hord, 1987; Loucks & Hall, 1977; Wedman et al., 1984). Loucks and Hall have described a typical progression in teachers' concerns and their ways of viewing a new teaching approach. Initially teachers focus on the mechanics of the innovation and on its impact on their own lives. As they become more comfortable carrying out the new approach, it becomes more routine and less visible, and they focus more on its effects on their students. If they see positive effects, they may progress to an interest in expanding the innovation and encouraging others to try it.

This progression in the focus of their concerns dictates a corresponding evolution in the kinds of resources and supports that teachers seek. In keeping with this pattern, teachers with very little experience of computers often want a gentle introduction, paced to prevent their feeling overwhelmed by the machinery. As teachers become familiar with the hardware and software, they become more concerned about how they can apply this technology to their particular classroom goals, students, and circumstances. As they plan computer-based lessons they may want support from an advisor in their classroom who can help demonstrate effective management techniques and consult about ways of organizing lessons. Even veteran teachers report that a lab aide is invaluable to help deal with students and machines who do not perform as expected. Still other teachers may not want advice so much as they want easy access to hardware to reduce the logistical burden of teaching in a way they know perfectly well how to do. This variation clearly suggests that teachers' needs must be assessed before they can be satisfactorily met (Winkler, 1985; Winner, 1983).

Hardware and Software

With this warning duly noted, it is still informative to review the kinds of resources that teachers in our study desired. Access to hardware and software were mentioned frequently. Many teachers emphasized that location and scheduling of access to hardware are very important. Access both in the classroom (one to four computers with one large monitor) and in the laboratory was described as the ideal arrangement. Teachers who think computers should be used to teach computer literacy as a separate course often favor placing computers in laboratories (Reed, 1986). Given that many of the teachers in our study wanted to use the computer as a tool for teaching and learning in the subject areas, their preference for access to computers in their classrooms is not surprising.

Enticing Visions of Teaching With Technology

While teachers report that the quality of software is improving, many still lack clear visions of how to teach effectively with technology, how to organize their classes, how to weave the technology-based component into the rest of the course. Seeing experienced teachers in action is helpful, as are opportunities to talk with colleagues. Many of the most extensive users of computers participated in a supportive network of colleagues (in either their school or district) who stimulated new ideas, offered recommendations about problems, and celebrated accomplishments. Several of the more experienced users of new technologies remarked that reluctant teachers need to be shown clearly one way of using computers, either to alleviate their work outside class or to enhance some part of their classroom work. The veterans suggest that once new users become accustomed to one approach and see its value, they will gradually branch out to other uses oftechnology.

Effective Training and Follow-up Assistance

Teachers in our study mentioned several features of effective training that are consistent with other research on staff development (Showers et al., 1987; Ray, 1988). They emphasized the value of training with plenty of "hands-on" time to experiment with hardware and software that they could use in their classrooms (Cline et al., 1986; Sheingold, Martin, & Endreweit, 1985; Watt & Watt, 1986). They wanted follow-up assistance from advisors (Zigarmi, 1978; McDonald & Naso, 1986) who could not only answer questions about the technology, but also help them figure out how to incorporate the new approach into their curriculum and regular teaching activities (Doyle & Ponder, 1978; Stecher & Solorzano, 1987). Teachers noted the value of informal exchanges with colleagues engaged in similar innovations, echoing findings of previous research (Watt & Watt, 1986; Wiske, 1986).

Layers Of Support

Teachers who seemed most satisfied with their uses of educational technology were often the beneficiaries of several layers of support. This finding is consistent with a great deal of research (Loucks et al., 1982a; Meister, 1984) that clarifies the nature and necessity of support from administrators and colleagues to sustain innovation. These layers of support include:

- on-site aides to assist with logistics, e.g., lab aides who help set up equipment and arrange for maintenance
- a district computer coordinator to organize systems for reviewing and purchasing hardware and software and to serve as a computer "champion" (Rogers et al., 1985)
- colleagues with whom to exchange strategies and build an atmosphere that supports collegiality and experimentation (Little, 1982; Parker, 1971)
- a building principal to provide incentives such as time, money, and moral support (Farrar, 1987)

- district-level support for developing clear priorities around educational technology and assuring the allocation of resources to address these priorities (Sturdivant, 1983).

Clearly, particularly able and enterprising teachers can manage without some of these resources. But the majority of teachers need considerable assistance and encouragement to learn how to incorporate computer technology into their classrooms.

More Influence On Educational Technology Policy and Design

Besides these kinds of direct support for their work in classrooms, the teachers we studied also wanted to exert more influence over decisions about educational technology. Specifically, they regularly reported that decisions in their schools were not sufficiently informed by teachers' priorities and constraints. The same claim was made even more often at the district level and other more remote levels of the educational administrative system. While not all teachers wanted to participate personally in advising decision makers, many thought teachers' voices needed to be better taken into account.

Another area in which teachers wish to exert more influence is software design. Although relatively few teachers described software they themselves would like to design, many thought that educational software could be improved if it were developed in consultation with teachers. This recommendation echoes that made by several researchers (Char & Hawkins, 1987; Hawkins & Kurland, 1987) who have investigated software development and implementation.

Research

One final desire expressed by several teachers in our study was for research on the effects of computers on teaching and learning. Teachers recognized that their hunches about the impacts of computer-based approaches did not by themselves provide a firm basis for making further commitments and decisions regarding educational technology. The growing body of research on this topic (Chen, 1985; Hawkins & Sheingold, 1986; Jackson & Deal, 1985; Pea & Sheingold, 1987; Winker et al., 1985; Yin & White, 1984) recommends that effects be studied in conjunction with investigations into the implementation process. Such studies may reveal relationships between patterns of use and effects and may illuminate changes in the use of educational technologies over time. Many computer-based educational innovations aim to achieve goals not readily measured by standardized achievement tests. Thus, standard teaching experiments focused solely on traditional outcome measures are likely to overlook important effects resulting from the introduction of new technologies into the classroom. Several teachers in our study appeared to endorse the recommendation of researchers (Hawkins & Sheingold, 1986) who favor observational studies of classrooms to clarify the elements of classroom life where effects are likely to be discerned, including changes in the content and sequence of the curriculum; changes in student and teacher beliefs, attitudes, and behaviors; and redistribution of authority and responsibilities in the classroom.

POLICY ISSUES

The policy considerations offered here are drawn from needs and desires identified by the teachers we interviewed and are informed by the literature and the experiences of the study team members.

PERSPECTIVES

Being Clear about What We Mean by "Computers in Education"

A primary necessity in the development of policy is to distinguish among the ways and contexts in which computers can be useful in education. These include:

Computer science (a subset of mathematics as a discipline)
Computer literacy (general knowledge for the general population)
Computer as a management and administrative tool for teachers
Computer as an instructional tool

Each of these is a legitimate educational application of technology, and each has unique requirements and payoffs. In thinking about meeting needs, stimulating activity, or allocating resources, it is important to be clear about objectives and to consider which use is the appropriate target. In this study, our attention has been focused primarily on the computer as an instructional tool.

Computer As An Instructional Tool

We focus here on the teaching and learning of subject matter for a number of reasons. In our interviews, this is the use of computers that most teachers addressed and about which they voiced concerns. They indicated that integrating the computer into the curriculum is a common objective and a complex undertaking for which training and support are needed. In addition to representing accurately the views of the teachers we studied, we believe that at the elementary and secondary levels the use of the computer as an instructional tool provides the greatest potential for engaging the largest number of teachers and for affecting student learning most broadly.

The vision expressed by teachers is that the computer can have a significant effect on the content, skills, scope, and sequence of the curriculum and on the process of teaching and learning. Teachers who have been using technology extensively, as well as those who expect to use technology in their teaching, are interested in the potential of technology to support learning that is more open-ended than drill and practice. The vision is provocative and engaging for many, but a reality for only a few.

Integrating The Computer into Instruction: A Systems Approach

From the interviews and from our own experience, we know that integrating computers into the curriculum is no small effort. No one questions that the use of computers in education requires hardware. What may not be so apparent is that the use of computers as instructional tools, like the successful application of any significant technology, requires an integrated system of resources.

From the interview data, we can define the system requirements for using computers successfully as instructional tools. These are: adequate hardware, appropriate software, related courseware, a knowledgeable and skilled teacher, reasonable mechanisms for assessing learning and practice, technical assistance, and a supportive environment for teachers' professional growth and development. All are necessary; no subset is sufficient.

Being trained but not having access to hardware, the right hardware, or curriculum materials; having a computer in the classroom and not having the training to use it; trying a new instructional approach in isolation from other teachers, the principal, or the central office; buying computers with no plan for their use -- these are all complaints or cautions voiced by teachers. They are often a source of frustration and a reason for failure. While teachers, administrators, software/curriculum developers, or funders may elect to focus on one element of this system as a form of specialization or as a place to begin, it is important to recognize that any single element will be only a partial solution with limited scope and impact. Probably the most effective way to begin integrating technology into the curriculum is with a good answer to the question, "Technology, for what?"

As we support the development, implementation, or dissemination of programs that integrate the computer into instruction, we must consider all the elements of the system and ensure that none is ignored. This entails the linking of new information and resources with the knowledge, equipment, materials, and teacher support systems that already exist.

Building on What Is Known, What Is Available, and What Is in Place

There already exists a substantial base of knowledge, material, and activity on which to build efforts to integrate the computer into instruction. Education is high on the public agenda. Initiatives should capitalize on the interests and the existing initiatives of federal and state agencies, corporations, and foundations in school improvement, curriculum development, and teacher education. We should also take advantage of the self-interest of hardware manufacturers, publishers, teacher training institutions, and professional educational organizations. Formal and informal networks, collaborations, and partnerships are essential.

Over the last thirty years, significant investments have been made in school reform and improvement. As we look to integrate the computer into the curriculum, we should take advantage of what has been learned about introducing technology into education, about implementing and sustaining innovation in education, and about effective practice in areas such as teacher training and curriculum development. In considering the more general literature, we should be clear about how computers are similar to previous efforts and innovations and how they are different.

We know that many teachers, schools, and districts across the country are actively working on integrating computers into the curriculum. Some excellent pieces of software are available, as are large numbers of options for in-service and pre-service training programs, and instances where technology has been successfully integrated into the curriculum. New efforts should take advantage of what is already underway

and seek to focus energy and investment on those elements of the system that are missing or neglected. From our interviews with teachers, no single element stands out as the most pressing need.

Acknowledging and Supporting the Teacher as a Professional

While we commonly acknowledge that the teacher has ultimate responsibility for what happens in the classroom, we often define the teachers' role as the final link in a one-way delivery mechanism to students, ignoring the teacher as a professional and key resource in the system. In contrast to this perspective, an essential factor in every success story about computer use that we heard was teacher interest, enthusiasm, and initiative. We also heard about the trials and tribulations of working with technology and curriculum and about the importance of informal, teacher-to-teacher problem-solving and support. If we want teachers to integrate the technology into their teaching, to learn new skills, to take on difficult challenges, we need to respect their professional judgment, to listen to them, and to provide them with the time and the opportunities to learn, to experiment, and to share.

As we move to integrate technology into the curriculum and to implement this vision, we must recognize the diversity of teacher experience, interests, and concerns as well as more obvious factors such as grade level and subject matter. To whet the appetites of teachers and schools, we must create legitimate opportunities to incorporate new technologies incrementally, short of the full vision. Teachers and schools must have opportunities to explore, to move at their own pace, and to experience the potential of curriculum-technology integration.

POLICY CONSIDERATIONS

In contrast to other institutions in the society, elementary and secondary schools have been slow to pick up and incorporate computer technology. Too often, yesterday's state of the art is tomorrow's educational technology. For the majority of the field and the majority of teachers, integrated use of computers in the curriculum remains a practice at the cutting edge. To move this practice into the mainstream, teachers and schools need information and resources in the following areas:

1. Examples of what's possible.

Examples of how to use computers as instructional tools should be collected. This collection should represent a range of approaches along a number of variables, including grade level, subject matter, teaching/learning style, student population, computer functions (e.g., speech, color, graphics, speed, network), and computer configurations (e.g., one computer per class for presentations, one computer learning station for small groups of students, a computer laboratory). The duration of these examples should cover the continuum from "five-minute ideas" to year-long courses.

Teachers need tangible, accessible examples they can pick up and feel. They need examples they can consider in light of their own objectives, educational values, and strategies. They need examples they can discuss with one another and can examine and

compare among themselves and with administrators, so that local standards of review and evaluation can be established.

These examples will not be models for replication but, rather, visions of possibilities that might inspire adaptation or related work. Visual images of teachers and students in action will be a necessary complement to written descriptions, software, and teaching materials.

2. Examples of support and training

Along with examples of curriculum-technology integration, we need examples of training, assistance, and support that facilitate such integration. We understand from teachers the need for various layers of support and training, but again, we have no readily available collection of examples. Experimentation and variation should be encouraged, including program-specific approaches to training for initial installation, ongoing support, coaching, and troubleshooting. Teachers should be offered a range of opportunities for professional growth and development, which respond to the needs of the reluctant novice as well as the seasoned educational "hacker." There should be examples of collegial support and networking, mechanisms for delivering support, assistance, and resources at the building and district levels. Principals, subject matter specialists, and district level administrators need examples of how to structure and deliver support for the integration and maintenance of technology in the curriculum. Variables in this context should include: subject matter, grade level, geographic setting, size of district, technology or subject matter focus, and role of technology.

3. Information on results

In our survey, we found that teachers have no difficulty assessing whether an administrative or managerial use of the computer meets their needs. After a short exposure or brief training session, individual teachers can decide for themselves whether an electronic gradebook or a word processor will increase productivity.

Assessing instructional applications of computers, particularly those that are more open-ended in nature, is a more complex business. The question is not simply whether the old agenda can be accomplished more efficiently. We also need to consider whether the agenda has expanded, whether learning has broadened or deepened, and whether there are other benefits for teachers and students. If we neglect these questions, our efforts will be subjected solely to traditional "horse race" teaching experiments, perhaps dooming effective practices whose benefits do not fit the mold or the timing of standard impact measures.

We need to be able to provide teachers and administrators with much more information about the various instructional uses of computers. Through observation and documentation, we can collect data on how the use of the computer affects content, curriculum, teaching methods, the roles of teachers and students, and the relationships between teacher and students and among students.

We also need to develop effective techniques and instruments for assessing student learning. We need methods to define the kinds, pace, and depth of learning that various instructional uses of the technology promote.

Finally, we need to listen to teachers at all stages of preparing and integrating new educational technologies. Their knowledge, insights, and reactions must guide the design of materials, training activities, and support mechanisms.

Research on all these fronts will inform teachers' decisions about the use of technology and will contribute to the development of more effective software, related curriculum, and teacher education and support.

TWO NOTES

First, these considerations are cautious by design and point to no single policy direction (although some might consider this a policy direction in itself). Experience and information are simply not sufficient to identify crisp models or exemplary approaches. It is too soon to talk of mandates or tax incentives. The goal should be to open possibilities, not to close them off. The objectives appropriate at this time are: (1) to encourage creativity and experimentation, and (2) to require assessment and documentation.

Second, these considerations assume effective and far-reaching channels for the flow of information and examples. Dissemination must be taken seriously and budgeted accordingly. We need to take advantage of networks and mechanisms of state and federal agencies (e.g., National Diffusion Network, NSF Chatauquas, OERI Regional Educational Laboratories and Research Centers), professional organizations, and educational media. We need to tap into the marketing capacities of hardware manufacturers and curriculum and software publishers. Finally, we need to create opportunities for teachers and schools to talk to one another.

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APPENDIX

TELEPHONE SURVEY

I. BACKGROUND INFORMATION

Name

M/F

Current Position

Elementary/Secondary

Subjects and Grades Taught

Size of School

Educational Background

Years of Teaching Experience

Do you have computers in your classroom?

Do you use a computer in your teaching or in your schoolrelated activities?

How often do you use computers in the classroom?

How would you describe your classroom use of computers? Are you a nonuser, an occasional user, a moderate user, or an extensive user nonuser

II. COMPUTER USE

1. (skip for nonusers) How did you get started using computers?
2. What kinds of hardware and software does your school have?

   How many computers?

   Where are they located?

   Is this a good place for them?
3. (skip for nonusers) How do you use computers in your class?

   Type of use?

   As a demonstration devise with the whole class?

   As an activity center for individual students or pairs of students taking turns?

   In a computer lab?

   With all students?

   With high achievers?

   With remedial or poor students?

   With special needs students?

   With bilingual students?

   Purpose?

For drill and practice or tutorials?

For simulations and games?

For exploration and problem solving?

For games or simulations?

For word processing or some other applications?

For programming, computer literacy?

Frequency?

How often do you use computers?

What portion of class time is spent using computers?

4. Could you tell me why you don't use computers in your classes (or why you don't use them more extensively)?

   a. Is time a factor?

      In class, are there too many other demands on your time, too many things to do, material to cover? Outside class, do you have other priorities, too busy being involved in things that are more important to you?

   b. Is it a matter of personal preference? (philosophical & pedagogical reasons)

      Computers don't fit into how you want to teach?J

      Want to minimize the role of computers (and other technologies radio, TV/VCR, films)?

      Could you explain how the computer affects the classroom, and why that's undesirable?

      What other teaching tools or materials or aids do you prefer to use?

   c. Is it a matter of facilities or software?J

      Has your school provided adequate facilities for computer use? Is the software adequate? Are there so many software choices that it's overwhelming?

      Would better computer facilities or software alter your decision not to use computers?

   d. Do you believe that computers are here to stay or are they a fad?

      Do they remind you of other classroom innovations that have come and gone? What distinguishes a fad from a genuine innovation?

   e. Is it a matter of training? (mention that we will cover this topic in more detail a little later)

      Has your school or district provided any training? Have you had bad or frustrating experiences with training?

      Is there some kind of training that is not now available to you that might tempt you to use computers or to use them more often?

f. Is the technology too complicated, intimidating? Does that make you reluctant to use computers?

Perhaps you've made an effort to use computers and found it too frustrating, overwhelming?

Has the fear of the technology influenced your decision not to use computers in your teaching?

Have you been put off by computer enthusiasts who talk over your head, make you feel stupid or foolish or inadequate?

If the technology could be dramatically simplified, would that in any way change your decision not to use computers?

g. Lack of Support (topic will be covered in more detail a little later)

Have you been alone in your efforts to introduce computers into the classroom? Has the school administration not provided moral or monetary support? Are there no other teachers who can help you?

5. (skip for nonusers) Why do you use computers in your teaching?

Could you begin with your own personal reasons?

Student related reasons? (To expose them to the latest technology? To help them learn better? As a student motivator?)

To satisfy a school requirement?

6. Do you use computers outside class?

For schoolrelated work? (e.g., preparing class activities? for record keeping?)

Do you use computers for tasks unrelated to your teaching (e.g., word processing)? J

7. Do other teachers in your school use computers?J

Do you think your [use/nonuse] of computers is similar to that of other teachers in your school? How typical or atypical are you?

III. TRAINING AND SUPPORT

Training

1. Have you had training in the use of computers?

If not are you self-taught?

If yes, could you give us some details about your training?J

Preservice or inservice? Formal or informal?

Who initiated the training?

Why did you participate (mandatory, selfenrichment, tuition reimbursement)?

Where did the training take place?

Who paid?

in your classroom behavior?

in your teaching style?

in your role as a teacher?

in the content of what you teach?

2. (skip for nonusers) Has your use of computers changed over time?
3. (skip for nonusers) Has your attitude towards computers changed as you've gained more experience?
4. In your opinion, is teaching easier or more difficult with a computer? (can be asked of both users and nonusers)
5. Do you think computers have had an impact on students?

   On how they learn?

   On how well they learn, on the quality of their work?

   On student motivation?

   On the relationship among students in the classroom?

   On the relationship between you and your students?

   On student behavior?
6. Do you think computers have had an effect on the curriculum?

   Have new courses been created?

   Have the goals and content of traditional courses changed?

   Have you had difficulties integrating software into your curriculum?
7. Has your [use/limited use/nonuse] of computers changed your relationship with other teachers?

   Has the introduction of computers created divisions in your department or in your school (between "those who do" and "those who don't")?
8. (skip for nonusers) Has the introduction of computers into your classroom made teaching more exciting, challenging, frustrating, overwhelming?

   Are you more or less likely to continue as a teacher because of computers?
9. (skip for nonusers) Has your use of computers led to new roles outside the classroom? (e.g. computer coordinator, administrator, lecturer, teacher trainer, consultant, software developer?)
10. Has the computers led to new roles for other teachers you know?

    Do you know whether other teachers who use computers find their teaching more exciting, challenging, frustrating, overwhelming?

    Do you know whether they more or less likely to stay in teaching as a result of computers?

Was the training during school hours, after school, or during vacation?

What was the training like? (topics, presentation)

How long did the training last?

2. Was your training adequate?

What were its strengths and weaknesses?

What were the most important features of your training?

(Instructor competence, handson access, followup?)

In your opinion, was the training relevant to your teaching?

Support

3. Is there any institutional support for computer use?

From computer coordinators in your school or district?

From school administrators?

From other teachers?

From outside agencies (e.g. Boston Computer Society)?

Has the school or district made any money available to buy equipment?

to attend workshops or conferences?

to take courses?

to write software and/or curriculum materials?

Have you received any help in scheduling computer use or in integrating computers into the curriculum?

Do you belong to a computer network?

Do you meet with other teachers to discuss computer use?

Are there rewards associated with knowing about and using computers in your school? (e.g. release time, compensation)

4. What support would you like that is not now available to you?

a. (for nonusers and occasional users) Is there some support that is not now available to you that might tempt you to use computers or use them more extensively?

5. Is funding for computers in your district too high, too low, or just about right?

Over the past 5 years, has the level of funding for computers gone up, down, or remained about the same?

IV. EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

1. (skip for nonusers) Has the presence of computers in your classroom changed your teaching in any way?

What difference has the computer made in your teaching?

11. Are computers or computer resources distributed equitably in your school or district?

Among schools in the district?

Among programs in the school?

In your school, do all students seem to have equal access to the computer, or do some students seem to use computers more than others?

If there are differences in use, could you describe them?J

Are computers taking scarce resources away from other important areas? Can you describe these areas?

V. TEACHERS' INFLUENCE ON TECHNOLOGY

1. How are decisions about computers made in your school or district?

As a teacher, are you satisfied with how decisions are made concerning how much money is spent on computers?

on equipment purchases?

on training?

on how computers are used, now they are integrated into the curriculum?

Would you like to play a larger role in making decisions about how much money is spent on computers, and how they are used?

Has your teachers' organization or union been involved in computerrelated issues?

2. Ideally, how do you think computers should be used?

Used by all students or only certain groups of students?

Integrated into the entire curriculum or restricted to specific subjects?

Used regularly or only as a supplement from time to time?

Would you like to play a role in designing software for classroom use?

If you were to design a software program for use in your classroom, what would it do?

3. What's the most compelling reason for using computers in the classroom? For not using them?

VI. MISCELLANEOUS

Is there anything else you'd like us to know?